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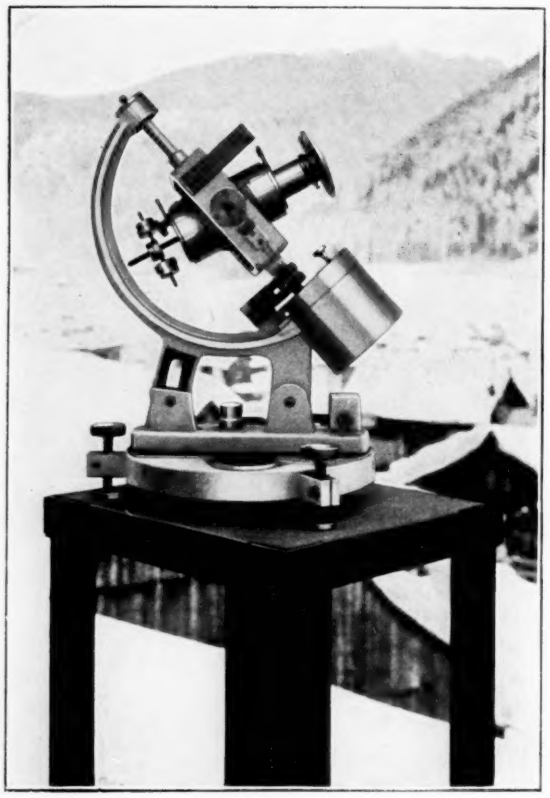

FIG. 1.—Pyrheliograph. (See p. 516.)

MONTHLY WEATHER REVIEW

ALFRED J. HENRY, Editor.

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OCTOBER, 1922.

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PROGRESS IN RADIATION MEASUREMENTS.

By C. Dorno.

[Davos, Switzerland, August, 1922.]

SYNOPSIS.

The author discusses apparatus that has been employed at the Davos Physical-Meteorological Observatory to measure the total solar radiation received at the surface of the earth, the intensity of radiation received from restricted regions of the solar spectrum, the intensity of irradiation, or outgoing nocturnal radiation from a black body, and also the radiation received at the earth's surface from the atmosphere. Especial attention is given to registering apparatus, principally of the photographic type.

A thermopile for measuring the total radiation, potassium and cadmium cells for measuring the radiation from the visible and the ultra-violet regions of the solar spectrum, and Ångström's tulipan for measuring nocturnal radiation find favor with the author.

In a brief summary of the Davos measurements it is shown that if we take into account the albedo of snow in winter and of the ground surface in summer, throughout the year "Hardly a third of the incoming radiation has contributed to the heating of the air and the melting [of snow or ice] and evaporation of moisture."

The results of recent medical researches are cited to show the value of the measurements of radiation intensity in the ultra-violet region of the solar spectrum.—H. H. K.

From its beginning in 1907 the Davos Physical-Meteorological Observatory has been endeavoring to develop reliable methods of registering sun and sky radiation, both as to their total intensity and also the intensity of the more important regions of the spectrum.

The author induced Carl Zeiss in Jena to construct for him a permanent spectrograph for ultra-violet radiation. This instrument was described in 1911.[1] Its chief object is to fix the variations in the extension of the sun's ultra-violet spectrum with the time of day and season. Quite lately the tables given (*l. c.*) have met with an unexpected and keen interest, since Hausser and Vahle [2] have proved by their very careful researches that the pigment-forming power properly belongs to a very small portion of the spectrum with a sharply pronounced maximum between the lines 0.302 and 0.297μ, from which the effect upon the epidermis sensibility falls rapidly on both sides (the research has not been extended to the mucous membrane). In *Strahlentherapie*, Band XIV, Heft 1, the author has stated the interesting biological and evolutional conclusions this result may lead to. It is of special interest to medicine, especially to the therapy of tuberculosis of the lungs, since years ago Rollier and others advanced the thesis that healing result and pigmenting power are proportional.

In this Review [3] a method of registering local atmospheric clearness has been described; that is to say, the physiological action of sun and sky on the human eye is measured in terms of its effect on the horizontal plane by the photoelectric method, by means of a highly evacuated potassium cell, at a low potential (2 to 4 volts) under milk-glass and filter (Schott F 5899). This is a very reliable and easy mode of registering radiation for a spectrum region of the greatest practical importance. In the same paper the author has given data to prove that under conditions of high altitude the nocturnal effective radiation may be registered with sufficient correctness by means of Ångström's tulipan,[4] which is based on the overdistillation of ether. Comparisons between the records of Ångström's tulipan and the pyrgeometer are being continued. The indications of the former are in error only if the greatest possible condensation for Davos occurs; then they are about 15 per cent too high; that is to say, only during the time of actual condensation, not in the nocturnal mean. Therefore corrections are generally unnecessary. Farther on, this mode of registry of radiation will be more fully treated. There is also mentioned a method of registry of the nocturnal effective radiation by means of the pyrgeometer, the compensation being eliminated, by photographic indication of the oscillation of a sensitive galvanometer. This method is not to be used, except on perfectly calm nights in midwinter, since the faintest breath of air is also recorded

The chief aim in these endeavors must be the construction of a reliable pyrheliograph for the purpose of registering the solar radiation in absolute heat units or calories. The author has sketched in rough outline a pyrheliograph which combines the principles on which Michelson's actinometer and Ångström's pyrheliometer are based. These outlines were elaborated in detail by Dr. Rud. Thilenius in Darmstadt, and the copper body and the thermocouple were constructed by him. The firm of A. Pfeiffer, in Wetzlar, undertook the construction of the other parts of the instrument. (See frontispiece.)

Registering sun intensity by means of a thermo element seems very simple to an outsider, but whoever is acquainted with the historical development of the pyrheliometer remembers that for a whole century the most prominent scientific men have been occupied with the problem of how to keep off the radiation influence of the surroundings, when making radiation measurements, before they were satisfactorily solved. In the present case—as with Michelson's actinometer—the result has been attained by putting the sensitive thermocouple in a small camera of a massive cylindrical copper body of 3 kg. weight, whose large capacity keeps the caloric variations of the surroundings sufficiently damped, and whose great transmissibility brings about the temperature compensation around the small camera very rapidly. Care is taken that in the forepart of the camera plenty of reflection leads the last traces of stray rays back to the intercepting surface. The back of the camera has been carefully blackened in order to absorb all the rays that may have pierced through from the front. The cylindrical camera is 8 mm. in diameter and 23.92 mm. long; the thermocouple is exactly centered and stands symmetrical to the declination axis. It is 12.18 mm. long and consists of 18 elements of constantan copper with an intercepting surface of 30 mm. The latter is put slightly extrafocal (2.8 mm.) to the focal plane of a quartz lens of 20 mm. opening and 86 mm. focal distance which therefore shows in the focal plane objects of 1° angular extension 1.5 mm. in size. Owing to five diaphragms which can be put before the lens about $\frac{1}{1}$, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$ of the incoming intensity may be utilized, while a brightly polished shelter protects the copper body from insolation. The in-radiating sun and sky zone may, at will, be limited to 8.4 or 12.8 or 47. 8 arc-minutes from the limb of the sun by three exchangeable diaphragms lying in the focal plane. For permanent registration the front diaphragm of 7.06 mm. diameter and

[1] *Studie über Licht und Luft des Hochgebirges*, Vieweg, 1911.
[2] *Strahlentherapie*, Band XIII, Heft 1, Seite 41 ff., Urban & Schwarzenberg, Berlin.
[3] Mo. Weather Rev., June, 1920, 48: 348-351.

[4] *Nova acta Regiae Societatis Scientiarum Upsaliensis*, Ser. IV, vol. 2, Nr. 8, 1910.

the largest back diaphragm are used, which lets in a sky zone of about three-fourths degree of arc. Small deviations in the day run are inevitable, partly on account of the variability of the solar declination during the day and partly because the mounting of the instrument, which is attached on the roof of the house, does not possess astronomical fixity; but the chief reason is the slight variations of the clock due to the great variations of temperature. With this arrangement the galvanometer readings remain unchanged even when the diopter image deviates half its diameter from its exact centering. The temperature developing inside the copper part could be controlled by means of an added thermometer. Even under extreme conditions it did not nearly attain the critical temperature of 50° C. at which the shellac of the thermocouple might have softened. Under the stated conditions, the thermocouple indicates at full insolation about 0.546 millivolt, so we were obliged to put in a resistance of 2,000 Ω before the Hartmann & Braun mirror galvanometer of 1.16×10^{-9} of sensitiveness, whose resistances was 1,000 Ω.

When the sun is shining brightly the registered readings vary, according to the solar altitude, between 135 and 60 mm. (1 mm. = 0.01174 cal.), an hour interval corresponds to 20 mm. width. Owing to the slight heat capacity of the thermocouple which, in spite of its minuteness, can not be made to disappear entirely, there exists a somewhat greater inertia of the galvanometer, which amounts to that observed with the registering by means of Ångström's pyranometer. During the galvanometer's period (hardly 10 seconds) 63 per cent of the incoming intensity may be registered. The rise progresses in the form of a steep exponential curve; but the last seventh follows slowly in about 1½ minutes. In permanent registry there results automatically a slight compensation of the curve which, however, is hardly noticeable with the scale used.

The maxima, which must show more distinctly with permanent registering than with single measurements, were nevertheless lower during the registering period (October, 1921, to June, 1922) than the absolute maximum. For 11 years (1910–1921) since March 5, 1910, the latter has been 1.575 (Smithsonian Scale Revised, 1913) and was only surpassed May 6, 1921, after a snowfall with 1.587 at 55° solar altitude.

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A comparison for all days between the number of registered calories by the pyrheliograph and the number of calories derived from registrations of Campbell-Stokes heliograph (sunshine duration times number of cloudiness) indicates 3½ per cent higher registered values.

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The frontispiece shows the instrument from the side view in the place where it is set up. The polar axis rests with globe-shaped pivots in the cylindric layers of a latitude arc of +-shaped cross section, which is adjustable in the limits 35° and 65° by means of a clamp at the edge. The lower part forms a console. This carries (1) the clockwork with the minute dial and (2) the springs of copper, which are insulated with slate and whose places of contact are plated with 0.2 mm. of fine gold. The rings, also, which are borne by an ivory ring, laid over the lower end of the polar axis, are of electrolytic copper with 0.2 mm. plating of fine gold; so the thermoelectric effects remain extremely minute. The conducting wires of the column are led through the hollow axis pivot (visible in the figure) of the declination axis, and joined to the gliding rings over copper transmission fixed to the frame part of the polar axis. On the other side of the declination axis is a volute wheel with 360 cogs and degree scale on the front surface, into which a tangent screw encroaches for the fine adjustment in declination. Its drum scale indicates 1′. Waterproof covered azimuth-correction screws, whose full rotation produces 30′ azimuth change, permit the full adjustment in the meridian. A lens diopter permanently controls in the easiest manner the correct adjustment of the axis of the tube parallel to the radiation, a number of counterweights regulate the compensation of the masses, so the clockwork remains uninfluenced in all the different positions of the copper part. The copper part consists of a right and a left half; they are joined by a front and a back centering cover and by three strong screws passing across. When these are loosened, the small camera inside, which contains the thermocouple is accessible. The lens tube (to be seen on the cut) with screen, front and rear diaphragms and quartz lens is carefully put in the copper part by means of a cone and is kept in the front centering cover by hinges and pressed into the copper part to the complete contact of the surface. Doctor Thilenius will soon publish a minute description of the pyrheliograph in the *Zeitschrift für Instrumentenkunde*.

Owing to the skill of Doctor Thilenius a still smaller miniature thermocouple of 12 elements of special alloys has been constructed, which, when fully exposed to the sun, gives about 4 millivolt, a power which would enable us to replace the photographic by a mechanical registration.

The instrument, which has been in permanent operation since October, 1921, i. e. now more than 10 months, has stood all tests. Comparisons with Ångström's compensation pyrheliometer have given the relation 1 mm. = 0.01174 cal., the deviations from this relation keep within one unit of the fourth decimal and are in nowise systematic with one exception; when the sun is low and the sky not quite clear, the relation always rises to 4 per cent. The reason for this is not to be found in a different reaction to the irradiating intensity, but in variations of the intensity. As has been said above, the pyrheliograph permits only a sky sector of ¾° of the edge of the sun to irradiate, the Ångström-Michelson silver disk instrument, however, a much larger one of about 5°. Thus the pyrheliograph gives the more exact (the smaller) readings. This question having been treated elsewhere [5]), we shall not enter upon it here. Of the results realized we shall only mention the following:

If monochromatic filters are placed before the pyrheliograph, the intensity of separate parts of the spectrum may theoretically also be registered. But two misgivings exist: (1) The available filters are not sufficiently monochromatic and especially not sufficiently examined as to their transmissibility in the ultra-red spectrum; (2) owing to the absorption of the incoming radiation the filter itself becomes the source of long-wave heat radiation, which vitiates the measured results. This latter danger may be met by leaving a sufficient air layer between the filter and the opening; the former can only be avoided in the red spectrum. The otherwise excellent Wratton-gelatine filters must be transparent to ultra-red rays, else they could not, contrary to proved laws, record at sunrise smaller intensity increase in blue-violet than in green, and in green smaller than in red. Red glass Schott F–4512 has proved highly monochromatic and seems to be opaque to ultra-red. After deducting the absorption of the 2 mm. filter, there resulted for the mean of the year the following true red portions of the total intensity as a function of the air mass (S):

S	$\frac{\text{Red}}{\text{White}}$
1.1	0.602
1.3	0.609
1.5	0.617
2.0	0.636
2.5	0.654
3.0	0.673
3.5	0.692
4.0	0.711
5.0	0.748

[5] *Abhandlungen des Preussischen Meteorologischen Instituts*, Band VI, 1919, p. 61.

An annual variation in the red portion is clearly to be observed. It rises at first rapidly, then slower from October till March; in April and May it diminishes but slightly; June, July, and August show changing values, for the most part below the spring values, but sometimes surpassing them by far. In the atmosphere of autumn, rich in water vapor, the red portion falls again from September to the October minimum. Parallel measurements made by this method at Davos (1,600 m.) and Potsdam (100 m.) show that in the clear month of October the red portion of the solar spectrum at Davos at 20° solar altitude is 7 per cent, and at 30° solar altitude is 4 per cent, smaller than at Potsdam.

In this periodical [6] A. Ångström and the author gave an account of the pyranometer, constructed by Ångström, its slight imperfections, its appropriateness for registering with compensation eliminated, and the first results realized at Davos in November and December, 1920. The registering has been carried on during an entire year (November, 1920, to October, 1921). Another slight imperfection of the instrument has been found: When permanently used the white magnesium oxide loses its delicate freshness; minute quantities of the light powder detach themselves under the influence of heat and artificial dryness, and disappear without visible traces when the instrument is moved into a room to be protected during the night or for other measurements. A slight hue of green then lies on the white. According to the diminution of the reflective power the constant of the instrument increases. It is difficult to re-whiten the two strips on account of their position between the black strips, besides there exists the danger that the magnesium smoke might at the same time touch the thermo elements. Therefore the author did not dare to do it himself. Rose, of Upsala, however, carried it through in May and June, and as a result registrations were secured for two decades in May and one in June. The constant, that has been permanently controlled, as was described,[7] kept satisfactorily at 12.93 from November to the middle of February; then, for the reason mentioned, it rose slowly to 16.66 on May 6. After the return from Upsala the instrument, whose strips had been newly whitened, recorded the value 12.90, but in the heat of summer and being sometimes intermittently used for other purposes, it rose to 15.53 at the end of July and at the end of October to 20.50. This imperfection and the inconvenience of having to calculate the registered readings with changing factors in calories might be avoided, or at least be reduced to a minumum, if the instrument could be kept free from every disturbance.

The readings of the pyranometer and those of the new pyrheliograph could to some extent be compared with each other. The difference of registered solar + sky radiation, which falls on the horizontal surface, and the sky radiation alone, fixed by single measurements, must be about equal to the solar radiation falling on the normal surface times the sine of the solar altitude. The comparisons were satisfactory and proved the reliability of the readings of both instruments. The radiation of a cloudless sky on a horizontal surface may increase the direct solar radiation by 18 per cent in the brighter spring and autumn; in the summer months, with an atmosphere rich in water vapor, by 24 per cent (relative to the mean of the day totals). On clear autumn days it amounts to—

Solar altitude:	Cal.
10°	0.020
15°	0.038
21°	0.053
25°	0.075
35°	0.080
40°	0.075
45°	0.079

Bright cumuli raise it to 20 per cent, even if they cover only one-tenth of the sky; bright stratus at solar intensity S_{2-3} raise it to the 3 or 4 fold value. As highest value of sky radiation was found 0.406 cal. at 44° solar altitude, the sky being bluish white with föhn. On cloudless days the absolute maximum of sun + sky radiation was 2,165 (in June after a snowfall at 66° solar altitude). Only once, on September 5, with clear sunshine and clouds combined, has it been surpassed—by the extraordinarliy high value 2.491, when the whole sky was covered with light gray nimbus clouds which the sun pierced suddenly. Of course the general action of clouds lessens radiation. In the yearly mean the normal values lose 21 per cent through it; in the three winter months only 19 per cent, in the three summer months, however, 27 per cent.

During the same period (November, 1920, to October, 1921) the registering of nocturnal radiation has been carried on by means of the tulipan during all the favorable nights, beginning and ending with a solar depression of 6°. The very considerable material obtained enabled the author to make the sums of the effective radiation and of the radiation of the atmosphere derived from it, and to examine into the influence of cloudiness, as well to its degree as to its kind.

TABLE 1.—*Nocturnal effective radiation A and radiation of the atmosphere E.*

[Integration values of the whole night from 6° after sunset to 6° before sunrise.]

Date.	Temperature.	Abs. humidity.	A	S	E	E_{20}
1920.	°C.	Mm.				
Nov. 19	−5.3	0.93	0.236 (0.177)	0.420	0.184	0.264
Dec. 25	1.2	2.78	0.181 (0.172)	0.463	0.282	0.368
1921.						
Jan. 25	−4.6	2.33	0.179 (0.161)	0.425	0.246	0.349
Feb. 23	−6.6	1.47	0.215 (0.165)	0.413	0.198	0.290
Mar. 10	−2.7	1.72	0.215 (0.174)	0.437	0.222	0.307
Apr. 2	2.1	3.84	0.194 (0.162)	0.460	0.275	0.354
May 6	−3.8	2.61	0.203 (0.161)	0.430	0.227	0.319
June 28	9.9	6.74	0.185 (0.156)	0.524	0.339	0.390
July 10	9.1	6.38	0.198 (0.156)	0.518	0.320	0.373
Aug. 8	12.7	8.56	0.179 (0.151)	0.545	0.366	0.405
Sept. 13	7.0	5.85	0.200 (0.155)	0.503	0.303	0.363
Oct. 10	6.2	4.77	0.207 (0.161)	0.497	0.290	0.352

REMARKS.

Nov. 19 means night from Nov. 19 to 20.
Radiation constant = 8.184×10^{-11}.
A = Effective radiation.
S = Computed radiation of a black surface.
E = Radiation of the atmosphere.
[a] E_{20} = Radiation of the atmosphere of 20° C.
The numbers in parentheses are Ångström's parallel values.

The table shows that on perfectly cloudless nights the effective radiation depends more on the humidity of the atmosphere than on its temperature. The radiation of

[6] Mo. WEATHER REV., vol. 49, No. 3, p. 135-138. [7] *Loc. cit.*

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[5] *Abhandlungen des Preussischen Meteorologischen Instituts*, Band VI, 1919, p. 61.

An annual variation in the red portion is clearly to be observed. It rises at first rapidly, then slower from October till March; in April and May it diminishes but slightly; June, July, and August show changing values, for the most part below the spring values, but sometimes surpassing them by far. In the atmosphere of autumn, rich in water vapor, the red portion falls again from September to the October minimum. Parallel measurements made by this method at Davos (1,600 m.) and Potsdam (100 m.) show that in the clear month of October the red portion of the solar spectrum at Davos at 20° solar altitude is 7 per cent, and at 30° solar altitude is 4 per cent, smaller than at Potsdam.

In this periodical [6] A. Ångström and the author gave an account of the pyranometer, constructed by Ångström, its slight imperfections, its appropriateness for registering with compensation eliminated, and the first results realized at Davos in November and December, 1920. The registering has been carried on during an entire year (November, 1920, to October, 1921). Another slight imperfection of the instrument has been found: When permanently used the white magnesium oxide loses its delicate freshness; minute quantities of the light powder detach themselves under the influence of heat and artificial dryness, and disappear without visible traces when the instrument is moved into a room to be protected during the night or for other measurements. A slight hue of green then lies on the white. According to the diminution of the reflective power the constant of the instrument increases. It is difficult to re-whiten the two strips on account of their position between the black strips, besides there exists the danger that the magnesium smoke might at the same time touch the thermo elements. Therefore the author did not dare to do it himself. Rose, of Upsala, however, carried it through in May and June, and as a result registrations were secured for two decades in May and one in June. The constant, that has been permanently controlled, as was described,[7] kept satisfactorily at 12.93 from November to the middle of February; then, for the reason mentioned, it rose slowly to 16.66 on May 6. After the return from Upsala the instrument, whose strips had been newly whitened, recorded the value 12.90, but in the heat of summer and being sometimes intermittently used for other purposes, it rose to 15.53 at the end of July and at the end of October to 20.50. This imperfection and the inconvenience of having to calculate the registered readings with changing factors in calories might be avoided, or at least be reduced to a minumum, if the instrument could be kept free from every disturbance.

The readings of the pyranometer and those of the new pyrheliograph could to some extent be compared with each other. The difference of registered solar + sky radiation, which falls on the horizontal surface, and the sky radiation alone, fixed by single measurements, must be about equal to the solar radiation falling on the normal surface times the sine of the solar altitude. The comparisons were satisfactory and proved the reliability of the readings of both instruments. The radiation of a cloudless sky on a horizontal surface may increase the direct solar radiation by 18 per cent in the brighter spring and autumn; in the summer months, with an atmosphere rich in water vapor, by 24 per cent (relative to the mean of the day totals). On clear autumn days it amounts to—

Solar altitude:	Cal.
10°	0.020
15°	0.038
21°	0.053
25°	0.075
35°	0.080
40°	0.075
45°	0.079

Bright cumuli raise it to 20 per cent, even if they cover only one-tenth of the sky; bright stratus at solar intensity S_{2-3} raise it to the 3 or 4 fold value. As highest value of sky radiation was found 0.406 cal. at 44° solar altitude, the sky being bluish white with föhn. On cloudless days the absolute maximum of sun + sky radiation was 2,165 (in June after a snowfall at 66° solar altitude). Only once, on September 5, with clear sunshine and clouds combined, has it been surpassed—by the extraordinarliy high value 2.491, when the whole sky was covered with light gray nimbus clouds which the sun pierced suddenly. Of course the general action of clouds lessens radiation. In the yearly mean the normal values lose 21 per cent through it; in the three winter months only 19 per cent, in the three summer months, however, 27 per cent.

During the same period (November, 1920, to October, 1921) the registering of nocturnal radiation has been carried on by means of the tulipan during all the favorable nights, beginning and ending with a solar depression of 6°. The very considerable material obtained enabled the author to make the sums of the effective radiation and of the radiation of the atmosphere derived from it, and to examine into the influence of cloudiness, as well to its degree as to its kind.

TABLE 1.—*Nocturnal effective radiation A and radiation of the atmosphere E.*

[Integration values of the whole night from 6° after sunset to 6° before sunrise.]

Date.	Temperature.	Abs. humidity.	A	S	E	E_{20}
1920.	°*C.*	*Mm.*				
Nov. 19	−5.3	0.93	0.236 (0.177)	0.420	0.184	0.264
Dec. 25	1.2	2.78	0.181 (0.172)	0.463	0.282	0.368
1921.						
Jan. 25	−4.6	2.33	0.179 (0.161)	0.425	0.246	0.349
Feb. 23	−6.6	1.47	0.215 (0.165)	0.413	0.198	0.290
Mar. 10	−2.7	1.72	0.215 (0.174)	0.437	0.222	0.307
Apr. 2	2.1	3.84	0.194 (0.162)	0.469	0.275	0.354
May 6	−3.8	2.61	0.203 (0.161)	0.430	0.227	0.310
June 26	9.9	6.74	0.185 (0.156)	0.524	0.339	0.390
July 10	9.1	6.38	0.198 (0.156)	0.518	0.320	0.373
Aug. 8	12.7	8.56	0.179 (0.151)	0.545	0.366	0.405
Sept. 13	7.0	5.85	0.200 (0.155)	0.503	0.303	0.363
Oct. 10	6.2	4.77	0.207 (0.161)	0.497	0.290	0.352

REMARKS.

Nov. 19 means night from Nov. 19 to 20.
Radiation constant = 8.184×10^{-11}.
A = Effective radiation.
S = Computed radiation of a black surface.
E = Radiation of the atmosphere.
E_{20} = Radiation of the atmosphere of 20° C.
The numbers in parentheses are Ångström's parallel values.

The table shows that on perfectly cloudless nights the effective radiation depends more on the humidity of the atmosphere than on its temperature. The radiation of

[6] MO. WEATHER REV., vol. 49, No. 3, p. 135–138.

[7] *Loc. cit.*

the atmosphere, however, depends more on the temperature. Since temperature and humidity counteract each other in their effect on the effective radiation, the yearly variation is slight, and only the clearest months of spring and autumn show high values. The yearly run of the radiation of the atmosphere, however, shows, as was to be expected, great amplitude—nearly 1 : 2 (0.184 in November and 0.366 in August) from the cold to the warm season. Compared to the effective radiation values calculated from A. Ångström's formula [8])—

$$E_{20} = K - C - 10^{-\gamma p}$$
$$K = 0.439$$
$$C = 0.158$$
$$\gamma = 0.069$$
$$p = \text{vapor pressure in mm.}$$

those found at Davos are 23 per cent higher, in perfect correspondence to A. Ångström's[9]) proportional numbers for different altitudes (0 meter, 0.44; 1,500 meters, 0.34). This results from the addition of the corresponding columns. This conformity proves once more that the atmospheric conditions of the Swiss Alps and the Californian Sierra where Ångström has collected the material for his formula are very similar.

Of 123 nights whose mean cloudiness at the beginning and at the end has been taken into account the following percentage loss could be derived for the cloudiness degrees 10 and 5, as compared with the effective radiation resulting under the same conditions of humidity and temperature when there were no clouds:

	Ci.St.	A.St.	St.Cu.	Nb.
B_{10}	30	60	80	94
B_5	16	33	45	52

If we express the relation between cloudiness and effective radiation with Ångström's formula—

$$A_m = (1 km) - A_o.$$

m = degree of cloudiness (in tenths of the covered sky surface)
A_m = effective radiation at this degree of cloudiness
A_o = effective radiation with cloudless sky
k = constant

the following constant values for the different kinds of cloudiness will result:

Ci.St.	0.031
A.St.	0.063
St.Cu.	0.085
Nb.	0.099

The results of observation and calculation with other degrees of cloudiness agree satisfactorily. Compared with results of the lowlands it seems that the influence of cirri is greater in the high mountains. This is hardly to be wondered at, since they add a screen of equal thickness to a relatively thick one already existing in the valley, and to a relatively thin one at the high altitude.

Admitting that the long-wave radiation of the day sky corresponds to that of the night sky, based on C. G. Abbot's and A. Ångström's measurements during solar eclipses, the long-wave radiation of the day sky has been calculated according to Ångström's formula from absolute humidity and temperature from the three observation times for all days from twilight to twilight, of which the night total has been observed, using the well-known formula $\frac{a+2b+c.}{4}$ For the other 195 days, of which no nocturnal observations were available, the mean $\frac{a+b+c}{3}$ was used to calculate the radiation of the 24-hour day. Of the radiation values to be expected with a cloudless sky under the same conditions of humidity and temperature the fraction resulting from the formula $A_m = (1 - km) A_o$ (for the four different k values mentioned above) was taken for every kind and amount of cloudiness. In the values of the monthly radiation totals thus received the maxima are again to be found in the months known to be the clearest; the amplitude, however, is much greater, 1.6 from June to March, and cloudiness exerts a greater influence than either temperature or humidity.

Finally, the whole heat exchange by radiation has been derived from this material (1) for the effective prevailing conditions, (2) under admission of a cloudless sky.

Table 2.

EFFECTIVE TOTAL CHANGE OF HEAT BY RADIATION, NOVEMBER, 1920, TO OCTOBER, 1921.

Month.	Inradiated.	Outradiated.	Gain (+), loss (−).
1920.	*cal.*	*cal.*	
November	5,730	5,925	−195
December	4,376	4,641	−265
1921.			
January	4,770	3,819	+951
February	8,608	5,220	+3,388
March	14,577	6,084	+8,493
April	15,847	3,872	+11,975
May	16,671	3,904	+12,767
June	18,616	3,766	+14,850
July	19,832	4,897	+14,935
August	15,847	4,296	+11,551
September	14,037	5,152	+8,885
October	11,118	5,787	+5,331
Year	150,029	57,363	+92,666

THEORETICAL COMPUTED CHANGE OF HEAT; CLOUDLESS SKY.

Month.	Inradiated.	Outradiated.	Gain (+), loss (−).
1920.			
November	6,061	10,200	−4,139
December	5,248	8,079	−2,831
1921.			
January	6,651	7,991	−1,340
February	10,039	8,668	+1,371
March	15,661	9,596	+6,065
April	20,516	8,381	+12,135
May	23,542	9,061	+14,481
June	27,287	7,993	+19,294
July	24,620	8,839	+15,781
August	22,501	7,991	+14,510
September	15,682	8,640	+7,042
October	12,722	9,241	+3,481
Year	190,530	104,680	+85,850

The effective yearly heat exchange shows with 92.7 kilogram-calories per square centimeter a somewhat greater gain (8 per cent greater) than the theoretical one; the reason for it is this: the outgoing radiation is diminished 45 per cent and the incoming only 21 per cent by the clouds. With a continually cloudless sky the months of November to January, when the sun is lowest, would bring a considerable loss of heat through radiation, but in reality we find it only in the months of November and December, when their cloudiness is not considerable and even then not in a high degree. Altogether 38 per cent of the incoming radiation was returned and 62 per cent

[8] *Smithsonian Miscellaneous Collections*, vol. 65, No. 3, 1915.
[9] *Meteorologische Zeitschrift*, 1916, p. 534.

was retained. This calculation holds for the absolutely black surface and changes completely if we take into account the albedo of the earth's surface. If we put for the incoming radiation during the five months with snow cover (December to April) the snow absorption 0.3 (albedo[10] in the mean 0.7) and during the seven months without snow cover the mean absorption of meadow and stone 0.9 (albedo[10] meadow 0.06, gravel 0.13), while the long-wave effective radiation remains unchanged (for according to J. Maurer's measurements and from theoretical reasons the snow radiates like a black surface, and the same may be admitted of the vegetation, humus and stone cover) we get:

Incoming radiation in December–April	14, 453
Outgoing radiation in December–April	23, 636
Outradiated	9, 183
Incoming radiation in May–November	91, 666
Outgoing radiation in May–November	33, 727
Inradiated	57, 939
Incoming radiation in the year	106, 119
Outgoing radiation in the year	57, 363
Inradiated	48, 756

In reference to the total incoming radiation indicated by the black surface (150,029 according to Table 2) only 32.5 per cent was retained in the year, and 67.5 per cent was given out by radiation; in summer 38.6 per cent retained and 61.4 per cent given out; in winter the whole incoming radiation besides 6 per cent more was given out. So hardly a third of the incoming radiation had contributed to the heating of the air and the melting and evaporation of the precipitation. Under the conditions of the highland valley with its thin atmospheric envelope and its five-month snow cover, two-thirds of the incoming radiation has conserved radiation energy through back radiation, and only one-third is transformed into heat—another proof for the high importance of radiation for the high-altitude climate.

It is true the albedo values taken into account are based on photometric determinations, and it still remains to be proved, whether they also hold good for other parts of the spectrum, especially the infra-red ones. According to investigations in different parts of the spectrum carried on at Davos, the albedo of newly fallen snow rises slowly but systematically from ultra-violet through blue, green, to yellow and even to red. It is not improbable, that the albedo of meadow and stone would also increase toward the infra-red end of the spectrum; that would give the result still more point. However, the difference of the albedo values is only an apparent one, produced by the heterogeneity of the light sources acting simultaneously. The solar radiation, which is rich in yellow and whose incidence is determined, is more intensively reflected from the surface of the ice crystals than the blue-sky radiation whose incidence is diffused.

PERMANENT REGISTERING OF THE ULTRA-VIOLET SOLAR RADIATION, NOVEMBER, 1920, TO JUNE, 1922.

Permanent registration of ultra-violet radition offers to meteorological optics the fairest prospect of continuous data relative to the degree of optical purity of the atmosphere; for its variations may best be noticed in the short-wave spectrum. One may especially expect to obtain evidence on the variations of the amount of ozone in the high atmosphere—an element which surely is very important—and on a parallelism of the variations of the optical transmissibility with the rotation period and with single revolutions of the sun.

A parallactically mounted cadmium cell, supplied with a thin argon filling, and made to follow the sun by means of a clockwork, was exposed under a mat uviolglass[11] at a distance of 112 mm. therefrom on which an image of the sun of 10 mm. diameter was projected by a quartz lens of 53 mm. diameter. The uviolglass disc having 30 mm. diameter, only $\frac{1}{2}°$ sky zone round the sun radiated in upon the cell. The resulting photocurrent was conducted through a mirror galvanometer of 8.55×10^{-11} at 1-m. scale distance and was photographically registered. Günther & Tegetmeyer, Braunschweig, have constructed the instrument with their wonted precision, and it is similar to the well-known electric photometer for visible light, made in the same workshop. The uviolglass is only employed in order to spare the cell and especially to protect it from too great heat. In the latter respect the precaution may have been exaggerated, for cadmium melts in vacuum only at 320° C. under a simultaneous vapor pressure of 0.001 mm., which, however, is below that of the argon-filled cell; but in the former respect the precaution was absolutely necessary. For, although the uviolglass was used, the following phenomenon could be observed. In order to obtain sufficiently high readings an auxiliary potential of about 160 volts was necessary. With it the day curves always show a perfectly symmetrical course, whose accuracy is absolutely not to be doubted. The sensitiveness of the cell, however, decreased continually during the registering period of $1\frac{3}{4}$ year. The decrease of sensitiveness can be stated by comparison with cadmium cell II, which has not changed since 1915. The latter has been employed to make only single measurements, and its sensitiveness has been constantly controlled by a controlling cell.

During the first days, while only experiments were made and comparisons were unfortunately not yet carried on systematically, the decrease of sensitiveness was very considerable (about two-thirds of the original sensitiveness). Later on, its fall was nearly linear and continued to go slowly down, every month, so that now, after 20 months of permanent use it possesses only about half of the original sensitiveness. The reverse of an uniform measure was operated, as has been told, by reduction to the regularly collected parallel readings of cell II. Whether this decrease of sensitiveness is caused by the loading up of the glass in proximity of the anode, or by an invisible thin cadmium layer on the platin ring of the anode, or by changes of the surface, or perhaps of the gas filling, has not been investigated. A change of poles, which might have given information, has been intentionally omitted, in order not to disturb the uniformity of the series. Grounding of the positive pole, which was done three times a day, in order to fix the zero line, did not operate to change the curve line of the zero line, not even at noon after half a day's permanent irradiation. Neither was there a decrease of sensitiveness observed after a long period of fine weather, when the exposure could last for weeks, nor when after long interruption by a period of bad weather, registering could again be taken up. Registering was carried on during all undisturbed days. The considerable material, which

[10] *Abhandlungen des Preuss. Meteorolog. Inst.*, Band VI, 1919, p. 214.

[11] A technical term for a glass that transmits far into the ultra-violet.—EDITOR.

resulted, confirms anew the yearly run which has been fixed by single measurements since 1909, as follows:

With the same solar-altitude there is a minimum in midsummer, and a maximum in midwinter; months of the second half year show greater intensity than the months of the first half year; especially is autumn intensity much greater than spring intensity. The intensity rises from 8 to 340, while the sun is mounting from 10° to 65°. The transmission coefficient is 0.229 in the yearly mean in 1921, while it was 0.253 in 1916 and 0.278 in 1917. The increased observational material collected, and which has not been confined to the finest days, explains, at least to some extent, the deviation toward a diminution of the transmission coefficient. The absolute numbers are somewhat lower than in the preceding years, which, to a small extent, may be owing to the loss of radiation in the small zone surrounding the sun, which has just been mentioned. If we look at all the long series from 1915 to 1922, we have, in spite of the numerous gaps, the convincing impression that the ultra-violet solar intensity (not taking into calculation the yearly run) has, generally speaking, decreased permanently from 1915 to 1922, from 1915 to 1917 rapidly, afterwards more slowly. Only the values of the extraordinarily clear days in the latter part of autumn 1920 and 1921 are an exception. The accuracy of this result may of course be doubted. There may be objections, viz, that even the best-protected standard cell of the observatory (No. II), which was used for single measurements only, may have diminished somewhat in its sensitiveness. However, it has from time to time been controlled by cell No. I, which until the autumn 1921 was used only for controlling purposes, and no change in the relation of sensitiveness could be ascertained. Even though we were inclined to correlate the result with the sunspot period, we should have to come to the conclusion, that just in the beginning of the increased activity (spot eruption) the emitted radiation was most considerable and not at the time of the maximum size of the spots. It will need a much greater amount of material, permanently registered and collected at different places of the earth, to substantiate this result.

An influence of the rotation period could not be established with certainty during this time of slight solar activity. Cirro-stratus alone weakens even in its lightest shape the ultra-violet radiation of the sun's disc 10 per cent, while the total intensity is only decreased half as much. The ultra-violet maximum values coincide in the same season with the clearest and bluest sky; they are found after snowfall and together with foehn descending into the valley. On days with tendency to thunderstorms they do not appear, as the zinc ball photometer erroneously indicates—most probably the error is due to the humidity of the air. Also the sudden and quick jumpings, which this instrument records, do not exist in reality and may also be due to the cause just mentioned. The registering curves run undisturbed on all cloudless days. The tendency of the atmosphere to condensation shows itself very soon and very characteristically in the ultra-violet solar radiation. When cumuli arise, radiation undergoes a small loss; a greater one, however, when alto-cumuli arise. The telluric solar corona, which the author measured, described and explained in former publications [12], lessens the ultra-violet solar radiation little, if any, and the registering curve runs perfectly undisturbed. The case is different with the obtrusive, dazzling white corona, which is the first sign of tendency to condensation. Under its influence the curve is constantly slightly wavering, and it also lies somewhat below the normal level.

Besides its great advantages, accuracy and possibility of registering the galvanometric method presents also a considerable disadvantage to measurements in ultra-violet. The instrument is not transportable. The very slight photo-current, produced by the cadmium cell, needs an extremely sensitive galvanometer, that must be most carefully protected from vibrations and all influences from outside, and whose foundation must be very firm. However, a special way of employing the cadmium cell is to be advocated here, which remedies this defect. K. Kähler [13] first inaugurated this method in Kolberg. Nine months ago it was adopted here with slight changes. This electrometric method may best be called the *discharging* method in opposition to the *charging* method. The cell, which stands in connection with a Wulf electrometer, is charged up to a certain potential, whose discharging velocity under the influence of ultra-violet radiation gives the measure of intensity. In order to diminish the too great intensity, suitable diaphragms were used here. They are easily switched on in the well-known "Electric photometer for visible light." An auxiliary capacity was not needed. There existed at first strong misgivings as to whether the described application would be possible, and whether the photo-current would always remain proportional to the incident intensity, the cell used being neither evacuated nor in a state of saturation and the connection between the current and the potential at constant illumination being not given linear but by the characteristic. Innumerable comparison measurements made with the registered values galvanometrically recorded, and also those with two cells used simultaneously according to this discharging method, have proved that the method is reliable, if the following important points are considered:

(1) In the limits of the discharge the characteristic of the cell must have a linear course.

(2) In the limits of the discharge the characteristic of the electrometer must have a linear course.

(3) The positive, not the negative, pole must be charged in connection with the electrometer (in order to avoid photo effects on the electrometer).

(4) A too nearly exhausted cell must not be used—only experiences with normally argon-filled cells are at hand.

If these rules are observed, this simple mode of measurement will prove astonishingly efficient. Having only a bifilar electrometer at my disposal and being therefore unable to fix quite exactly the crossing time of a certain scale division by means of a stop watch, I adopted the following expedient: Within a large scale area, in which the characteristics of the cell and the gauge curve of the photometer run lineally, the discharge area was but approximately adhered to (with the Davos instrument between 150 and 100 volts) and the readings were taken immediately before and after the exposure, while the fibers stopped. The measure was then the following:

$$\frac{10000}{t}\left(\log\frac{V_0}{V}-\frac{V_0^1}{V^1}\right)$$

t in seconds

V_0 and V beginning and end potential with radiation

V_0^1 and V^1 beginning and end potential without radiation for the controlling of insolation.

[12] *Abhandlungen des Preussischen Meteorologischen Instituts*, Vol. V, p. 5, 1917.

[13] *Abhandlungen des Preussischen Meteorologischen Instituts*, Band VII, Nr. 2, 1920.

I multiplied by 10,000 to get easy numbers. The insolation loss always kept below 1 per cent, except at quite low solar altitude, and was generally negligible. I always made three measurements, of which the mean was taken. At constant sun their variations keep within narrow limits; they mostly amount to about 1 per cent of the mean value. Sudden jumpings like those occurring with the zinc ball photometer were not seen. The time of discharge was regulated by different large diaphragms, and nearly always varied between the limits of 12 and 25 seconds.

The method is especially fit to be used in fixing the ultra violet local clearness by switching in several mat quartz plates. The diminution of radiation, which ensues, is fatal to the galvanometric method, but in this case it is generally desirable. Further, this method has been applied to the comparison of the intensity of the quartz lamp (so much used in medicine now) and that of the sun within that ultra-violet spectrum section, which both kinds of radiation have in common. Ten different burners partly new, partly old ones were examined. The exact data were published in "Strahlentherapie," Band XIV, Heft 1 (Urban & Schwarzenberg, Berlin). The result, which will interest most here, is: The Hanauer quartz lamp, supplied with a new burner (so called *Künstliche Höhensonne*) furnishes:

At 100 cm. distance..	3.7 fold	sun intensity, in relation to Davos
At 70 cm. distance..	6.1 fold	sun intensity at the mean of sun's
At 50 cm. distance..	12.2 fold	altitude.

Some simultaneous comparison measurements, made in Chur (587 m.), Davos (1,590 m.), Schatzalp (1,860 m.), furnished the result that within these altitudes with a cloudless sky observation and calculation from transmission coefficient (the different sea levels being taken into consideration) are in good agreement, except during special weather conditions. For instance, when there is a foehn prevailing, decending far into the valley of the Rhine, while it passes above the Davos valley, then there arise above the latter light strata, recognized by the whitish blue color of the sky, in the former. However, the air is then of the highest possible transmissibility—in this case the Chur values have been considerably higher than those resulting from calculation.

INFLUENCE OF COVER CROPS ON ORCHARD TEMPERATURES.

By FLOYD D. YOUNG, Meteorologist.

[Weather Bureau Office, Los Angeles, Calif., October 1, 1922.]

Among the growers of citrus fruits in California the belief that the presence of a cover crop in a citrus grove greatly increases the frost hazard has been growing rapidly during the past few years. Several reputable citrus growers have found much more damaged fruit in portions of their groves in cover crop than in clean cultivated sections. Other growers have stated that cover crops lowered the temperature of their orchards as much as 8° during frosty nights. As a result of this belief the tendency in orchard management has been away from winter cover crops.

Cover crops are considered by agricultural specialists to be of unquestioned value in maintaining the fertility of the soil and supplying humus. In some sections of California cover crops in citrus groves are considered to be absolutely necessary on account of soil conditions. Much additional irrigation water is required to grow summer cover crops in citrus groves, and where water is scarce summer cover crops are out of the question. Unless plenty of water is available for both cover crop and trees the cover crop will compete with the trees for moisture, with resulting injury to the tree. During most winter seasons in California there is abundant rainfall and winter cover crops can be grown without irrigation.

Early in the fall of 1921 the Weather Bureau was requested by officials of the Citrus Experiment Station at Riverside, Calif., to carry out experiments to determine to what extent, if any, a cover crop lowered the temperature on a frosty night.

A number of investigators had already studied this question by the simple expedient of selecting two groves, side by side, one in cover crop and the other clean cultivation, and making temperature observations in the two on frosty nights. Several years work in investigating frost conditions in southern California had demonstrated that such methods would be open to criticism. Differences in temperature of several degrees are often found within a few hundred feet on frosty nights, on ground which to the eye appears perfectly level. This being the case, differences in temperature observed between adjoining groves may be due entirely to causes other than the presence or absence of cover crops.

The plan of operation decided upon was as follows: It was desired to obtain a 10-acre orange or lemon grove in which the cover crop had attained considerable growth early in the fall, and divide it into two 5-acre sections. Temperature stations were to be installed at about the center of these 5-acre plots, the stations to be moved about until two points were found where the temperatures were as nearly the same as possible. After it had been demonstrated that there was a consistent relation between the temperatures at the two stations, the cover crop in one of the 5-acre plots was to be plowed under, and the ground cultivated thoroughly.

It was necessary to find a grove in cover crop which was surrounded by clean cultivation for some distance on every side, or to plow up a very large section of a grove in a neighborhood where all the groves were in cover crop. This is due to the fact that if the cover crop did depress the temperature to any great extent, this cooling effect would be felt some distance away over a clean cultivated area, due to the air drift which is practically always found in this section on a frosty night.

Much difficulty was experienced in finding a suitable grove, the owner of which was willing to plow under half his cover crop about two months earlier than usual. This was to be expected, since no money was available with which to make up the grower's loss. It finally was necessary to accept the offer of a 6-acre orange grove, near Pomona, Calif., belonging to Mr. H. J. Nichols. Mr. Nichols deserve much credit for his cooperation in this work, which was carried on for the benefit of all the citrus growers in the State.

DESCRIPTION OF THE GROVE.

The grove selected lies on practically level ground. Navel orange trees, 25 years old, are set 20 feet apart, shading a consiserable portion of the ground. The soil is a sandy loam, very deep, and without gravel. The cover crop consisted of *Melilotus indica* sowed 30 pounds to the acre, and rye, 10 pounds to the acre, with a scattering of purple vetch. Toward the end of the frost season the rye stood 2½ feet high, with a heavy crop of *melilotus* ex-

tending to a height of about 6 inches above the ground. (See figs. 1 and 2.) The grove was entirely surrounded by clean cultivated ground.

In spite of the fact that the ground was practically level, and the stations were only about 200 feet apart, it was necessary to shift the positions of the instrument shelters several times before the lowest temperatures on frosty nights at the two stations agreed within one-half degree.

EXPOSURE OF INSTRUMENTS.

Stations were finally located in the interior of the grove, one near the northern end and the other near the southern end. The instrumental equipment and exposure of instruments was the same at both stations. Fruit-region instrument shelters, containing minimum thermometers and 29-hour thermographs, were installed on supports at both stations, so that the thermometers were 5 feet above the ground. Fruit-region shelters, containing the same instrumental equipment, were set directly on the ground at both stations, the thermometers being 10 inches above the ground.

The two stations were designated "North" and "South" for the purpose of identifying them.

After the permanent locations for the stations had been selected, eight clear, frosty nights were allowed to pass, in order to establish a definite temperature relation between the two stations. Minimum temperatures registered on these nights are shown in Table 1. Minimum temperatures averaged 0.6° F. lower at the south station than at the north station during this period, both at the 5-foot elevation and in the shelter on the ground.

TABLE 1.—*Minimum temperatures, °F., on frosty nights (sheltered thermometers).*

[Entire grove still in cover crop.]

Date.	5-foot elevation.			10-inch elevation.		
	North plot.	South plot.	Difference.	North plot.	South plot.	Difference.
Jan. 6	31.3	30.5	−0.8	30.7	30.1	−0.6
9	30.4	30.1	−0.3	31.0	30.4	−0.6
11	35.2	34.4	−0.8	34.1	33.6	−0.5
12	32.1	31.9	−0.2	31.3	30.4	−0.9
13	29.0	28.2	−0.8	28.0	27.6	−0.4
14	31.3	31.4	+0.1	30.1	29.1	−1.0
15	31.5	30.6	−0.9	30.5	30.0	−0.5
16	31.0	30.0	−1.0	30.1	29.8	−0.3
Average	31.5	30.9	−0.6	30.7	30.1	−0.6

TABLE 2.—*Minimum temperatures, °F., on frosty nights (sheltered thermometers).*

[North plot clean cultivation; south plot in cover crop.]

Date.	5-foot elevation.			10-inch elevation.		
	North plot.	South plot.	Difference.	North plot.	South plot.	Difference.
Jan. 20	19.8	20.0	+0.2	19.4	20.0	+0.6
21	22.0	21.3	−0.7	22.4	21.0	−1.4
22	24.6	23.4	−1.2	24.0	22.7	−1.3
23	25.2	24.0	−1.2	25.0	23.1	−1.9
24	28.0	27.0	−1.0	27.5	25.0	−2.5
25	30.8	29.9	−0.9	30.0	27.0	−3.0
26	28.5	28.1	−0.4	28.0	27.0	−1.0
27	28.4	28.1	−0.3	28.2	27.1	−1.1
Feb. 1	28.1	27.8	−0.3	29.5	27.7	−1.8
2	28.4	27.2	−1.2	29.0	27.0	−2.0
3	25.1	24.3	−0.8	26.1	24.0	−2.1
4	27.0	26.0	−1.0	27.4	26.0	−1.4
5	28.1	27.6	−0.5	29.0	27.3	−1.7
6	32.4	31.7	−0.7	32.3	30.3	−2.0
Average	26.9	26.2	−0.7	27.0	25.4	−1.6

NORTH PLOT COVER CROP PLOWED UNDER.

On January 18, 1922, the cover crop in the north plot was plowed under, but the south plot was not disturbed. If the cover crop had been exerting a marked influence on the temperature, the temperature in the north plot (now clean cultivation) should now be considerably higher than that in the south plot, still in cover crop.

After January 18, when the cover crop was plowed under, temperature records were obtained covering 16 frosty nights, including the exceptionally cold period from January 19 to 23, the coldest weather that has been experienced in southern California since 1913. Minimum temperatures recorded at the two elevations in both plots each night during this time are shown in Table 2.

It will be seen that the average difference in minimum temperature between the two stations is only 0.7° F. at the 5-foot elevation, and 1.6° F. at the 10-inch elevation. Comparing these differences with the average differences between the two stations before the cover crop was removed from the north plot, it will be seen that the removal of the cover crop had practically no influence on the minimum temperature at the 5-foot elevation. At the 10-inch elevation there was a difference of 1.0° F. due to the removal of the cover crop.

These data indicate that under the conditions which prevailed during the period covered by these observations, the cover crop had practically no effect on the minimum air temperature during the night at a height of a few feet above the ground. The depression of temperature of 1.0° F. at 10 inches above the ground, which can be attributed to the influence of the cover crop, would not have much bearing on the amount of damage to fruit, since there is little fruit within that distance from the ground.

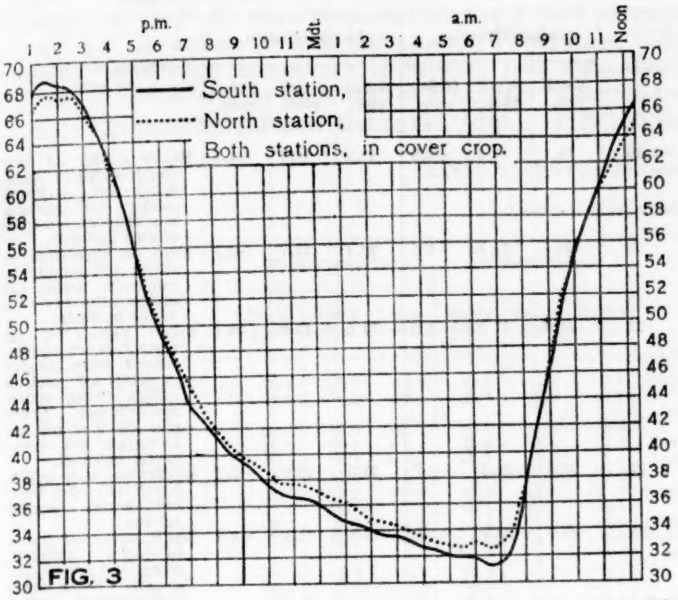
In order to note the influence of the cover crop on the rate of fall in temperature at night and the rate of rise in temperature in the morning, semihourly temperatures for 24-hour periods during each of the 16 days on which frosts occurred after the cover crop was removed from the north plot were averaged and plotted. To show what was the normal relation between the daily march in temperature at the two stations, semihourly temperatures for the cold nights before the cover crop was removed were also averaged and plotted. As 29-hour thermographs were used, and the records were checked frequently on cold nights, both as to time and temperature, it was possible to calculate these semihourly temperatures to tenths of a degree with considerable accuracy.

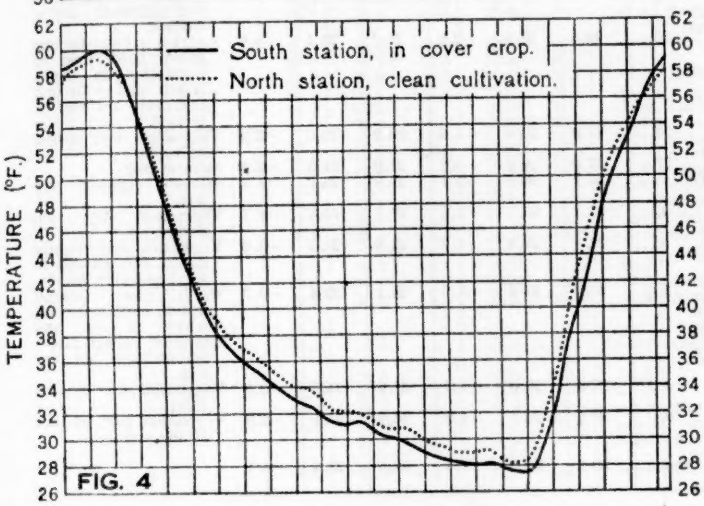
The average semihourly temperatures for the 5-foot shelters at both north and south stations during the period while the entire orchard was still in cover crop are shown in Figure 3. The same data for the period after the cover crop had been removed from the north plot are shown in Figure 4. These diagrams show that the only effect of the cover crop was to retard the rise in temperature in the morning about 15 minutes. At times during the rapid rise in temperature in the morning, the temperature was 2.5° F. higher in the clean cultivated plot than over the cover crop.

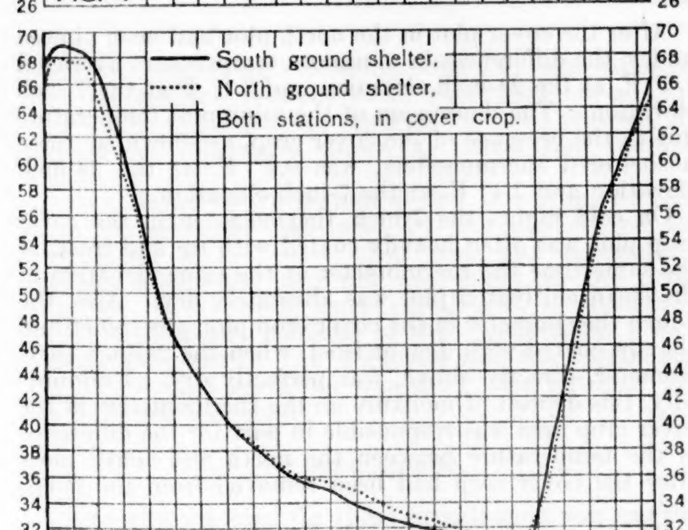
The effect of the cover crop was considerably greater at the shelter on the ground. A comparison of Figures 5 and 6, which show the difference in temperature at this elevation (10 inches above the ground) before and after the cover crop was removed from the north plot, brings out this point. The cover crop caused the temperature to fall more rapidly during the evening, and to rise more

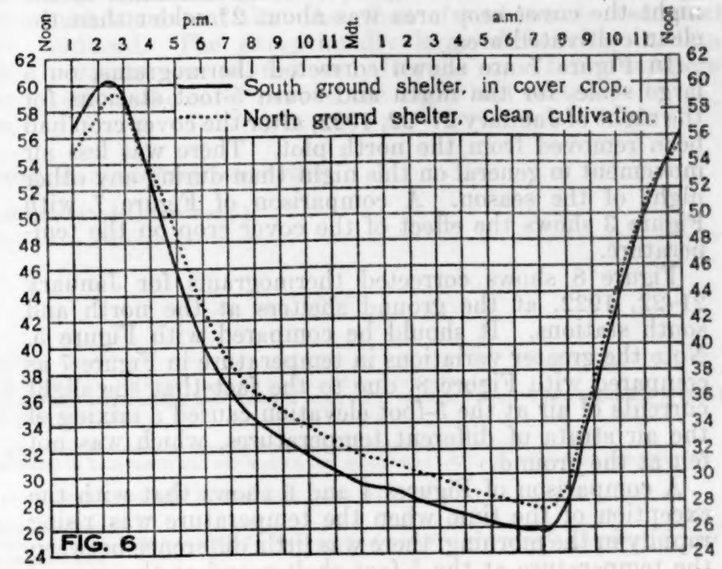
FIG. 1.—View of instrument shelter on ground in south plot, showing height of barley cover crop, February, 1922.

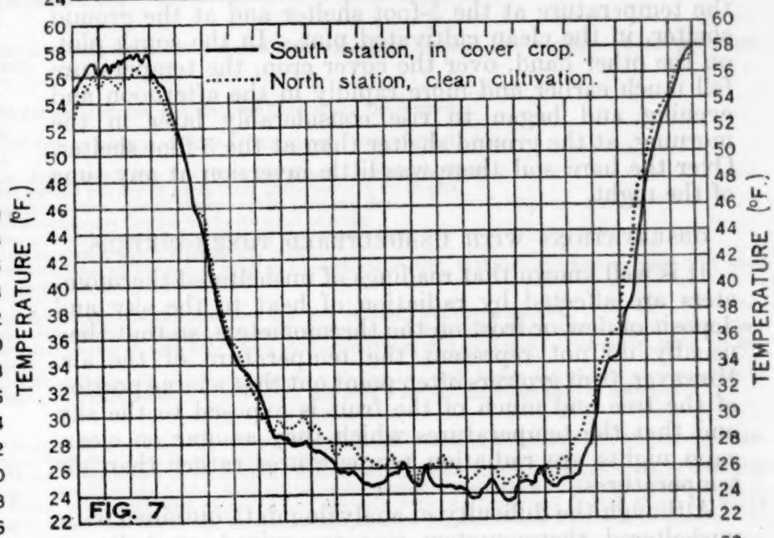
FIG. 2.—Unsheltered minimum thermometers in south plot. Lower thermometer is 7 inches above ground and upper thermometer 24 inches above ground.

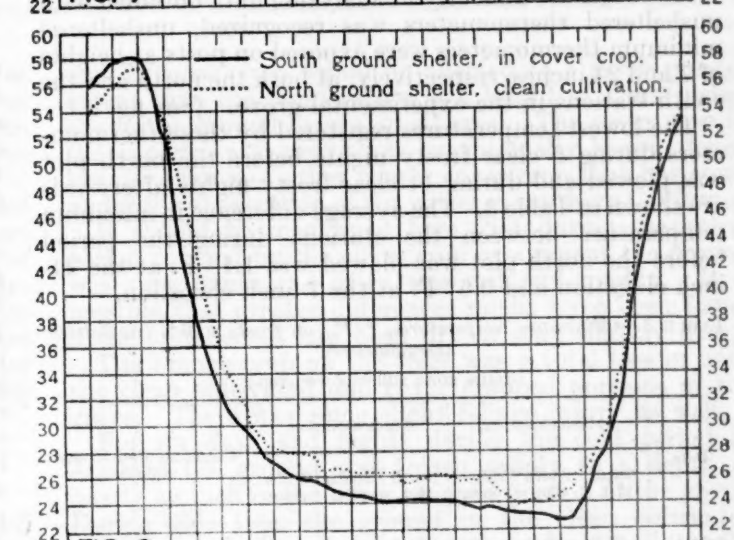

South station,
North station,
Both stations, in cover crop.
FIG. 3


South station, in cover crop.
North station, clean cultivation.
TEMPERATURE (°F.)
FIG. 4


South ground shelter,
North ground shelter,
Both stations, in cover crop.
FIG. 5


South ground shelter, in cover crop.
North ground shelter, clean cultivation.
FIG. 6


South station, in cover crop.
North station, clean cultivation.
TEMPERATURE (°F.)
FIG. 7


South ground shelter, in cover crop.
North ground shelter, clean cultivation.
FIG. 8

slowly in the morning. During the early evening the difference in temperature between the two stations was about 2.5° F., and during most of the remainder of the night the cover crop area was about 2° colder than the clean cultivated area.

In Figure 7 are shown corrected thermograms, on a large scale, for the north and south 5-foot stations for the night of January 21–22, 1922, after the cover crop had been removed from the north plot. There was less air movement in general on this night than during any other night of the season. A comparison of Figure 7 with Figure 3 shows the effect of the cover crop on the temperature.

Figure 8 shows corrected thermograms for January 21–22, 1922, at the ground shelters at the north and south stations. It should be compared with Figure 5. Note the greater variations in temperature in Figure 7 as compared with Figure 8, due to the fact that the slight currents of air at the 5-foot elevation caused a mixing of the air strata of different temperatures, which was not felt at the ground.

A comparison of Figures 4 and 6 shows that with the exception of the time when the temperature was rising rapidly in the morning, there was little difference between the temperature at the 5-foot shelter and at the ground shelter, in the clean cultivated plot. In the south plot, on the other hand, over the cover crop, the temperature fell much earlier and more rapidly in the afternoon and evening and began to rise considerably later in the morning, at the ground shelter than at the 5-foot shelter. Over the bare soil there was little inversion at any time of the night.

OBSERVATIONS WITH UNSHELTERED THERMOMETERS.

It is well known that readings of unsheltered thermometers are affected by radiation of heat to the sky and deposit of dew or frost on the thermometers, so that they usually do not represent the temperature of the air. However, fruit growers often point out that a large portion of the tree and much of the fruit is exposed to the sky and that the temperatures which they assume on clear, calm nights are radiation temperatures rather than air temperatures.

Although the difficulty in analyzing data obtained with unsheltered thermometers was recognized, unsheltered minimum thermometers were exposed on posts at heights of 7 and 24 inches, respectively, at both the north and the south stations in the experimental grove. (See fig. 2.)

The lowest temperatures registered by these thermometers during 6 clear frosty nights before the north plot was plowed and during 14 clear frosty nights afterwards are shown in Table 3. The average difference in minimum temperature between the stations during the period before the north plot was plowed was 1.1° F. at the 24-inch elevation and 0.6° F. at the 7-inch elevation.

TABLE 3.—*Minimum temperatures, ° F., on frosty nights (unsheltered thermometers).*

[Entire grove still in cover crop.]

Date.	24-inch elevation.			7-inch elevation.			Condition of cover crop at noon.
	North plot.	South plot.	Difference.	North plot.	South plot.	Difference.	
Jan. 11...	33.0	31.4	−1.6	31.1	29.9	−1.2	Quite wet.
12...	29.1	29.0	−0.1	27.5	27.1	−0.4	Do.
13...	27.0	25.8	−1.2	25.0	24.4	−0.6	Slightly wet.
14...	28.9	27.9	−1.0	26.6	26.0	−0.6	Do.
15...	29.6	28.0	−1.6	28.4	27.8	−0.6	Quite wet.
16...	29.0	27.7	−1.3	28.0	27.4	−0.6	Very wet.
Average..	29.4	28.3	−1.1	27.8	27.1	−0.7	

TABLE 3.—*Minimum temperatures, ° F., on frosty nights (unsheltered thermometers)*—Continued.

[North plot clean cultivation; south plot in cover crop.]

Date.	24-inch elevation.			7-inch elevation.			Condition of cover crop at noon.
	North plot.	South plot.	Difference.	North plot.	South plot.	Difference.	
Jan. 20...	18.1	17.2	−0.9	18.2	16.7	−1.5	Heavy deposit of frost on cover crop in shade. South plot soil frozen solidly. Soil unfrozen in north plot, but trace of frost in shade.
21...	20.4	18.9	−1.5	20.4	17.7	−2.7	Frost on vegetation in shade: soil muddy in sun, with frozen soil underneath; frozen solidly in shade.
22...	23.0	21.0	−2.0	24.0	19.6	−4.4	South plot—Frost on vegetation in shade; ground frozen solidly in shade; soft mud on surface; frozen underneath in sun. North plot—No frost; soil dry at surface; wet underneath; unfrozen.
23...	23.2	21.5	−1.7	23.3	20.0	−3.3	South plot—Same as 22d. North plot—No frost; soil frozen beneath surface.
24...	25.9	23.5	−2.4	25.4	21.1	−4.3	South plot—Soil frozen in shade; unfrozen, damp, but not muddy in sun. North plot—Soil unfrozen; dry at surface.
25...	28.0	26.0	−2.0	27.7	23.1	−4.6	South plot—Ground frozen hard: frost on vegetation in shade. North plot — Ground unfrozen; no frost on ground.
26...	27.0	25.4	−1.6	26.9	24.0	−2.9	Vegetation dry; ground unfrozen.
27...	27.0	26.2	−0.8	27.0	24.6	−2.4	Same as 26th.
Feb. 1....	27.7	26.0	−1.7	27.8	25.0	−2.8	Soil and vegetation very wet.
2....	27.1	25.5	−1.6	27.1	24.4	−2.7	Vegetation dry; soil damp.
3....	24.1	22.9	−1.2	24.6	21.3	−3.3	Vegetation only slightly damp, but ground in south plot very muddy.
4....	26.0	24.5	−1.5	26.1	23.4	−2.7	South plot — Ground frozen, except surface, which is wet and muddy. North plot—Soil unfrozen, but very wet.
5....	27.4	26.0	−1.4	27.6	24.8	−2.8	Vegetation dry: ground damp.
6....	30.9	29.7	−1.2	30.8	27.9	−2.9	Vegetation dry: ground drying rapidly
Average..	25.4	23.9	−1.5	25.5	22.4	−3.1	

After the cover plot in the north plot had been plowed under, the differences in minimum temperature averaged 1.5° F. at the 24-inch elevation and 3.1° F at the 7-inch elevation. The depression of the minimum temperature due to the presence of the cover crop, as shown by these unsheltered thermometers, was 0.4° F. at the 24-inch elevation and 2.4° F. at the 7-inch elevation.

On cold nights the 7-inch thermometer in the cover crop plot was often heavily coated with ice and frost, at the same time the thermometer at the same elevation in the clean cultivated plot was absolutely dry. Also, the 7-inch thermometer in the cover crop plot was sometimes heavily coated with dew or frost, when the 24-inch thermometer, directly above, was perfectly dry. Undoubtedly, this deposit of moisture on the thermometers in the cover crop area was responsible in part for the difference in the temperature between the north and south plots after the cover crop had been removed from the north plot.

During the period when the temperature was falling rapidly in the evening the unsheltered thermometers showed exceptionally large differences in temperature between the cover crop area and the clean cultivated area. This was particularly true of the thermometer at the 7-inch elevation.

Current temperature readings taken during clear nights after the north plot had been plowed are shown in Table 4. It will be noted that temperature differences of as much as 11.0° F. were observed at the 7-inch elevation and 8.7° F. at the 24-inch elevation. These large differences were only temporary, however, and were due in part to differences in the effect of temporary breezes over the bare ground and over the cover drop. Over the bare ground the mixing of air strata of different temperatures caused the temperature down to the ground surface to rise, while the cover crop interfered with this mixing to such an extent that the effect of such winds was much reduced. The exceptionally large differences in temperature were never noted after the rapid fall in temperature in the early part of the night had ceased.

TABLE 4.—*Current temperatures, °F. (unsheltered thermometers).*

[North plot clean cultivation; south plot in cover crop.]

Date.	Time.	24-inch elevation.			7-inch elevation.			Notes.
		North plot.	South plot.	Difference.	North plot.	South plot.	Difference.	
Jan. 19	9:00 p. m.	23.2	22.3	−0.9	23.4	21.1	−2.3	Frost on cover crop; soil frozen in south plot; not frozen in north plot.
	10:50 p. m.	23.6	21.1	−2.5	23.4	19.6	−3.8	South plot 7-inch thermometer frost covered; others dry; crust of frozen soil just beginning to form in north plot; dead calm.
20	1:00 a. m.	20.0	18.8	−1.2	20.0	18.0	−2.0	
	2:45 a. m.	21.0	18.6	−2.4	21.0	17.9	−3.1	South plot 7-inch thermometer heavily frost coated; others perfectly dry.
	3:30 a. m.	19.5	18.7	−0.8	19.7	17.8	−1.9	Ground frozen in both north and south plots, but much more solidly in south than in north plot.
	4:00 p. m.	43.9	43.8	−0.1	42.7	39.9	−2.8	
	9:05 p. m.	23.1	21.9	−1.2	23.3	21.0	−2.3	South plot 7-inch thermometer frost covered; others perfectly dry.
	10:50 p. m.	22.0	20.6	−1.4	22.1	20.0	−2.1	
21	3:55 a. m.	22.0	21.0	−1.0	21.8	19.0	−2.8	Cloudless; dead calm.
	9:45 p. m.	25.3	24.7	−0.6	25.3	22.4	−2.9	Cover crop stiff with frost; south plot 7-inch thermometer heavily frost coated; others dry; no trace of frost in north plot.
22	3:50 a. m.	24.0	23.6	−0.4	24.0	20.9	−3.1	
	4:15 p. m.	51.3	49.0	−2.3	49.1	42.0	−7.1	
	8:45 p. m.	35.5	34.0	−1.5	35.0	30.2	−4.8	South plot 7-inch thermometer coated with frost; others perfectly dry. Strong wind blowing temporarily.
	9:30 p. m.	31.1	28.8	−2.3	30.6	26.3	−4.3	
23	4:15 p. m.	60.0	56.2	−3.8	59.0	48.7	−10.3	
	9:15 p. m.	31.6	28.9	−2.7	31.3	26.0	−5.3	Light northerly breeze; cloudless; no frost on any thermometer.
24	4:05 p. m.	62.5	60.1	−2.4	61.9	55.2	−6.7	
	9:45 p. m.	41.9	33.2	−8.7	41.0	30.0	−11.0	Liquid dew on south plot 7-inch thermometer; others perfectly dry.
	11:00 p. m.	32.9	30.2	−2.7	32.1	28.0	−4.1	
25	6:45 p. m.	44.1	40.0	−4.1	43.7	36.3	−7.4	Calm; dew covers south plot 7-inch thermometer; others perfectly dry.
26	4:15 p. m.	65.5	63.6	−1.9	64.8	58.0	−6.8	Calm; surface soil dry in north plot; quite damp in south plot.
	6:00 p. m.	48.4	44.6	−3.8	47.0	38.5	−8.5	Calm; vegetation, and all thermometers perfectly dry.
27	4:15 p. m.	52.0	51.7	−0.3	52.0	50.6	−1.4	0.6 strato-cumulus clouds: moderate wind blowing.
	6:00 p. m.	46.9	45.1	−1.8	46.8	43.9	−2.9	Overcast with heavy, black stratus clouds; a little wind.
28	4:15 p. m.	47.6	46.6	−1.0	47.4	45.0	−2.4	Strong northwest wind; some clouds in sky.
	10:20 p. m.	27.6	27.1	−0.5	27.5	26.1	−1.4	Calm; cloudless; unfrozen dew on all exposed thermometers; both dew and frost on cover crop; frost on south plot instrument shelter.
Feb. 2	4:20 p. m.	48.4	48.5	+0.1	48.0	46.5	−1.5	
	7:45 p. m.	31.6	30.0	−1.6	31.5	28.0	−3.5	Calm; both north plot thermometers dry; dew on south plot thermometers.
	9:45 p. m.	29.5	27.9	−1.6	29.4	26.8	−2.6	North plot—Both thermometers perfectly dry; ground freezing. South plot—Bulb of 7-inch thermometer ice coated, with heavy frost on scale; unfrozen mist on 24-inch thermometer; calm; ground frozen.
3	3:15 a. m.	26.3	26.0	−0.3	26.7	24.3	−2.4	Cloudless; calm; north plot thermometers perfectly dry; both 7-inch and 24-inch thermometers in south plot coated with frost; vegetation stiff with frost; ground frozen hard in both plots.
	3:45 a. m.	26.2	23.9	−2.3	26.4	22.4	−4.0	
	4:10 p. m.	48.8	48.1	−0.7	47.7	42.7	−5.0	
	9:20 p. m.	29.5	28.8	−0.7	30.0	27.8	−2.2	North plot—Heavy liquid fog on both thermometers. South plot—Ice on lower thermometer; unfrozen mist on 24-inch thermometer; calm.
	9:40 p. m.	29.0	28.0	−1.0	29.1	26.6	−2.5	
4	3:45 a. m.	27.0	26.0	−1.0	27.5	25.0	−2.5	North plot—Frozen dew on both thermometers. South plot—Both thermometers heavily coated with frost. Cloudless; dead calm; heavy frost on vegetation; ground frozen hard in both plots.
	4:15 a. m.	26.3	25.0	−1.3	26.7	23.8	−2.9	Cloudless; calm; north-plot thermometers perfectly dry; both 7-inch and 24-inch thermometers in south plot coated with frost; vegetation stiff with frost; ground frozen hard in both plots.

There is a strong probability that the large differences in temperature between clean cultivated citrus groves and those in cover crop, reported by some growers, were temporary differences shown by unsheltered thermometers.

In so far as the formation of dew, ice, or frost affected the temperatures registered by the unsheltered thermometers in the cover crop area, the depression of temperature from this did not apply to the greater portion of the trees, since the deposit of moisture or frost was usually confined to the thermometer 7 inches above the ground. As a general rule the thermometer at the 24-inch elevation was dry. The notes in Table 4 bring out this point.

CONCLUSIONS.

The orchard used for these experiments was too small to indicate definitely what effect a cover crop covering a large area would have on the temperature. At the same time, it is not likely that the temperature at a height of several feet above the ground over a large area in cover crop would be affected to a much greater extent than the temperature at a height of a few inches above the ground over a small area. The cover crop in the experimental grove was exceptionally heavy; much heavier than any other winter cover crop that has come under the observation of the writer in southern California.

It should be mentioned here that during the entire period covered by the cover crop experiment the ground was very damp and often was wet and muddy. It is possible that greater differences might have been found if the surface soil had been dry or only slightly damp.

The orange crop on the trees was a total loss in both the clean cultivated and cover cropped portions of the grove. There was some slight foliage injury as well.

For six days and nights during the cold period in January the ground was frozen solidly to a depth of nearly an inch in the cover cropped portion of the grove. During this time the ground in the clean cultivated portion was frozen at night, but thawed out early in the morning. Toward the end of the extremely cold period, the soil in the clean cultivated area was sufficiently dry to prevent freezing at the surface. It is suggested that

this freezing of the surface soil, especially where continuing over so long a period as noted above, may injure the hair roots near the surface of the ground and thus weaken the tree.

TABLE 5.—*Effect of cover crop on amount of temperature, °F., inversion near ground.*

[Average minimum temperature on clear nights.]

SHELTERED THERMOMETERS.

	North plot.			South plot.		
	5-foot elevation.	10-inch elevation.	Difference.	5-foot elevation.	10-inch elevation.	Difference.
Both plots in cover crop	31.5	30.7	−0.8	30.9	30.1	−0.8
North plot in cover crop; south plot clean cultivation	26.9	27.0	+0.1	26.2	25.4	−0.8

UNSHELTERED THERMOMETERS.

	North plot.			South plot.		
	24-inch elevation.	7-inch elevation.	Difference.	24-inch elevation.	10-inch elevation.	Difference.
Both plots in cover crop	29.4	27.8	−1.6	28.3	27.1	−1.2
North plot in cover crop; south plot clean cultivation	25.4	25.5	+0.1	23.9	22.4	−1.5

The unsheltered thermometers show this in a somewhat greater degree. (See Tables 4 and 5.)

The bare soil probably was warmed up to a depth of 2 or 3 inches during the day, and this heat was conducted to the surface during the night, partially maintaining the temperature of the surface layer of air. On the other hand, the cover crop shaded the soil, preventing its warming up to any considerable extent during the day and also acted as an insulating agent between the surface of the soil and the surface layer of the air during the night.

It is not possible to draw a definite conclusion from observations covering only one frost season, but all the evidence obtained thus far indicates that a cover crop has little effect on the temperature a few feet above the ground. If this conclusion is borne out by experiments, which it is hoped to carry out in later seasons, any increased damage to fruit by frost in a cover-cropped citrus grove must be attributed to some other agency than a depression of the air temperature by the cover crop. If the greater damage found in cover-cropped groves can not be explained by natural differences in temperature, due to difference in elevation or other such cause, the answer may be found in a physiological effect of the cover crop on the tree.

One of the principal effects of the cover crop on the temperature is due to its shading the ground and thus preventing the warming of the soil during the day. This effect is discounted, however, in a citrus grove of old trees, because the trees themselves shade a large proportion of the ground and prevent the sun's rays from warming the soil to the extent that would be the case if there were no trees present. It readily can be seen that the effect of a cover crop in depressing the temperature on a clear, calm night would be greater in a grove of young trees, and still greater in an alfalfa field, without trees.

An interesting point brought out in this work was the fact that there was no temperature inversion within 5 feet of the ground over the clean cultivated area. There was a difference of nearly a degree between the 5-foot shelter and the ground shelter while the cover crop remained, but this difference disappeared entirely when the cover crop was removed. This is brought out in Table 5.

A SECOND EXPERIMENT ON COVER CROPS.

A second experiment with the object of determining the influence of a cover crop on the frost hazard was carries on by Mr. Eckley S. Ellison, observer, U. S. Weather Bureau, on the property of the Fontana Farms Co., near Fontana, Calif. That settlement is situated in extreme southern San Bernardino County about 45 miles due east of the town of San Bernardino.

Mr. Ellison's observations were made at the 5-foot level above the ground on a clean cultivated area and on one that was covered with grass and clover. A portion of the experimental plot was plowed under and the observations continued. His conclusions as given in his own words follow:

> Results obtained in this experiment tend to show that a cover crop increases the frost hazard, although the amount of the increase is so small as to be practically negligible. At a distance of 5 feet above the ground, the lowering of temperature amounts to less than half a degree F. Also the duration of critical temperatures is not affected to any practical extent regardless of the condition of the surface, whether cropped or clean.
>
> It might be that when large areas are planted to cover crops the influence on the temperature would be more marked, but it is the writer's belief that even then no considerable influence would result, due to the relatively small effect detected when a plot of 5 acres is used as a basis of comparison.
>
> Since the effect of a cover crop, although small, can be noted at an elevation of 5 feet, there is reason to suppose that from that height down to the surface of the ground a greater influence would be exerted. The results of this experiment can not, therefore, be construed to fit the case of a grower who has a considerable portion of his crop below the 5-foot level. Within the cover crop itself the influence of the vegetation is probably great—two or three degrees at least * * *.

—*A. J. H.*

CALCULATING TEMPERATURE EXTREMES IN SPOKANE COUNTY, WASH.

By E. M. KEYSER, Meteorologist.

[Weather Bureau, Spokane, Wash., October 19, 1920.]

Whatever degree of success was attained in temperature calculations in Spokane County last spring came as a by-product of the survey work authorized here by the Chief of Bureau. The original stimulus for undertaking these calculations came from a personal knowledge of the work being done in southern Oregon and California by Meteorologist Floyd D. Young. This stimulus was intensified by the various inspirational and very practical articles in MONTHLY WEATHER REVIEW SUPPLEMENT No. 16 (Predicting Minimum Temperatures From Hygrometric Data). The scope was greatly augmented by the willing and accurate clerical work done by Observer Frank B. Whitney, specially assigned to aid in the survey.

SCOPE OF 1922 TEMPERATURE SURVEY.

Spokane County, 54 miles long and 36 miles broad, touching Idaho on the east, reaches within 66 miles of the Canadian border. In the survey lasting from April 9 to June 13 temperature records were obtained from nine stations outside of Spokane, which is near the center of the county. Five of these were in Spokane Valley east of

the city and the other four in what is called the Deer Park section north of the city. Stations were all equipped with maximum and minimum thermometers in charge of orchardists. Six of the stations had thermographs and one key station in each district a sling psychrometer.

From these stations a body of valuable temperature data was obtained. Comparison of the records of the different stations brought out most interesting results. Particular attention was given to minimum temperature. It was found that the minima at the outside stations showed a range on some nights of as much as 11° among themselves and in a number of cases of between 10° and 20° as compared with the Spokane minimum. Report was made to the Central Office of the daily minima at each station and a detailed comparison of each minimum with the Spokane minima.

SPOKANE RECORDS IN CALCULATION CURVES.

Early in the season work was begun on graph making, which resulted eventually in a large number of useful station and field graphs by means of which, without use of formula, any assistant or cooperative observer, after having obtained the evening relative humidity and dewpoint, could easily calculate the approximate minimum temperature the following morning. The first graphs made were 5-year graphs based on all April and May Spokane records from 1917 to 1921, inclusive. It was immediately seen that in many cases these curves gave very close approximations to the Spokane minima 12 hours in advance. A little later similar dot charts were made for the April and May records for 1912 to 1916, inclusive. The deductions for the two sets were so nearly alike that we were greatly encouraged. Also, for variation, formulæ were worked out for the two sets and a table of corrections prepared for each possible humidity, to be applied to the dewpoint. This table required only simple addition and was used by the man on evening duty.

While deductions from these graphs gave next morning's minimum within 2° practically 50 per cent of the time and within 4° 75 per cent of the time, it was noted that the miss was at times as great as 8° or 10°. Different investigational plots were made and different researches gone into in an effort to solve the "miss" problem. While individual causes were discovered for poor approximations, the limited investigations we were able to make did not furnish us a clue to a principle worthy of general application. We had to content ourselves with the uncorrected approximations, which were, of course, for the Spokane station. Due to the probable wide divergence of the orchard minima from the Spokane minima the graphs were used with great hesitancy in trying to apply their results to orchard conditions.

GRAPHS FROM THE NEW FIELD DATA.

When the hygrometric data from the orchard key stations began coming in we soon started the construction of our field graphs. As the dots were entered from week to week we were astonished to find that they were falling along a usable curve. A final checking up on these field graphs showed that by the close of the frost season much more accurate approximations of the following morning orchard minima could be made by them than by the detailed 5-year Spokane graphs. These gave minima that were accurate more than 15 per cent of the time; within 1°, about 33 per cent of the time; 2°, 50 per cent; 3°, 60 per cent; and 4°, 70 per cent of the time. The other 30 per cent of the time the approximations ranged from 5° to 9° in error, except one case, which was 13° off. The graphs of the two stations were not equally accurate and the figures given are the means of the two stations.

ALL GRAPHS TO A PRACTICAL TEST.

The very practical value of these field curves was brought out on one or two mornings of the survey. The San Francisco district forecasts on the mornings referred to, based wholly of course on the daily weather charts, called for light to heavy frost in this vicinity. The local forecaster at Spokane confirmed the predictions and light to heavy frost was heralded through the usual cards and daily weather maps. The district evening forecasts, based on the 5 p. m. (local time) weather charts, repeated the warnings. On the two days referred to, the 5 p. m. field graphs gave deductions for minima well above freezing. Also the Spokane graph gave its rather questionable confirmation of the field calculations. The actual minima following these forecasts and calculations were well above the danger line, the freezing point not having been reached at any station. It was surprising what confidence in the mathematical curves was instilled in the local forecaster by these two occurrences.

5 P. M. GRAPHS FOR EVERY MONTH.

The possibilities of useful deductions from the use of parabolic curves made from hygrometric data by this time appeared as a great stimulus for extending the work to cover other portions of the year than the spring frost season. The fruit crop is subject to injury from low temperature in the autumn while on the trees, in storage, or in transit, and a foreknowledge of sudden temperature falls in the autumn or early winter might be as much protection to the orchardist as a frost warning in the months of April, May, and June. Similar dot curves were accordingly constructed for one of the fall months covering 10 years of Spokane records.

These charts, one each for clear, partly cloudy, and cloudy observations of the 5 p. m. readings, gave as accurate results for Spokane minima as did the spring charts. So we continued the making of these afternoon charts for other fall months, then the winter months, and finally we had three of the 10-year minimum temperature charts for each month of the year, all based on the 5 p. m. observations recorded in form No. 1001 and morning minima as recorded in form No. 1014. The late spring, summer, and early fall curves give the closest approximations and the winter curves the farthest. All are not only usable but very desirable in ascertaining the next morning's minima. The boundary lines of the dots mark the area within which the minima may be expected to be indicated almost 100 per cent of the time. In the great majority of cases the necessary factors will fall much closer to the curve, of course, than they do to the boundary line.

NOON MINIMUM GRAPHS MORE ACCURATE.

Success with the 5 o'clock graphs gave additional interest to charting. If 5 o'clock calculations give close estimates, possibly noon calculations might also. Graphs were accordingly made for one month of noon observations, using all of the 4 years' hygrometric and weather observations. The results were quite startling. The noon graphs in many cases gave more accurate deductions than did the evening. Convinced of this all,

the available noon data in the Spokane records were compiled and three graphs for each remaining month constructed. Application of the proper graphs to the 61 days of the 1922 survey gave approximations within 4° of accuracy 77 per cent of the time.

MAXIMUM GRAPHS MOST ACCURATE OF ALL.

These unexpected and astonishing results obtainable every day by the noon graphs in connection with minimum temperatures raised the query as to whether maximum graphs might not be practicable. Graph momentum was high now and but little additional work was needed to try out their accuracy. The data of dew point and humidity had already been compiled and checked and it remained only to copy them and work out the departures of the afternoon maxima from the noon dew points and plot them. The first set of these graphs gave remarkably close approximations which encouraged us to complete the 36 noon maximum graphs, 3 for each month. They were afterwards applied to all the Spokane maxima occurring during the 61 days of the temperature survey with the following percentages of accuracy: Within 1°, 52 per cent; 2°, 78 per cent; 3°, 89 per cent; and 6°. 100 per cent. It is admitted that a foreknowledge of the maximum is of less advantage than of the minimum, but it is conceivable that at times this advance information would be of value. At any rate it was of great interest to discover a clue to calculating it. When opportunity permits it is desired to apply the early morning or a mid-forenoon humidity data in an effort to arrive at an earlier determination of the afternoon maxima. A preliminary try out by use of the 5 a. m. hygrometric data was not particularly encouraging, but the matter is only in abeyance. During one or two heated periods this summer these graphs were found quite useful in informing the afternoon newspaper in time for publication whether previous records were likely to be equaled or exceeded.

GRAPHS ALWAYS USABLE, BUT STILL IN THE ROUGH.

It is realized that various observers who have used parabolic curves for estimating minimum temperatures have segregated the so-called "radiation" nights from the cloudy or rainy nights, but it is believed that these graphs have a universal practical application. In making the Spokane curves no nights were eliminated. The completed curves take into consideration every 5 p. m. reading and every morning minimum available. The deductions from them are therefore applicable for any kind of a night, within the range of accuracy represented by the dots. Some experimentation was entered into by segregating the radiation nights or nights with minima near freezing or below and plotting the corresponding 5 p. m. hygrometric observations. The graphs thus obtained gave practically the same results as did the all-inclusive graphs. It is not claimed for these comprehensive graphs that they are the last word in approximation. It is only held that they are of immense usefulness and are dependable guides for the local forecaster every day in the year. Moreover, they may act as emergency aids in the late afternoon when the local and district forecasters (using the weather map only) have overlooked an imminent sudden temperature drop or cold wave, such as may sometimes occur overnight.

Plans are in progress and in contemplation for working out usable corrections to be applied to the graph deductions. It is believed that they have already greatly

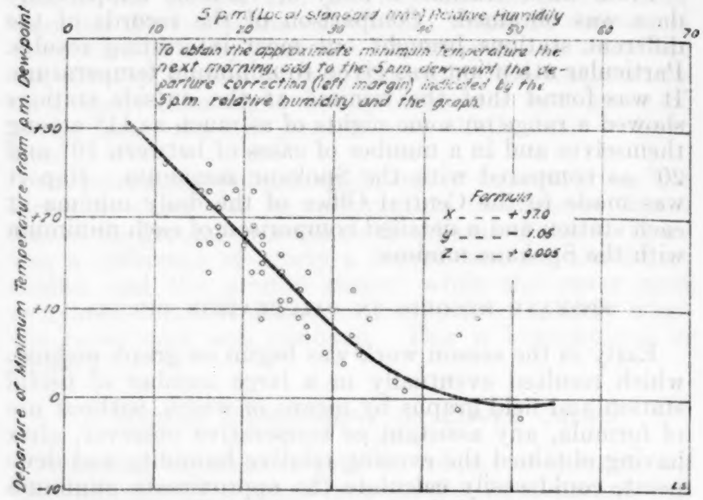


FIG. 1.—Minimum-temperature prediction graph for the months of April and May, 1917–1921. inclusive, at Spokane, Wash., based on all of the 5 p. m. *clear* observations for the period.

enhanced the Weather Bureau's usefulness not only to the apple industry but to many others as well.

Figures 1 and 2 show the minimum temperature forecast curves as calculated from the Spokane 5 p. m. hygrometric data for the months of April and May for 1917–1921. No. 1 covers all clear, and No. 2 partly

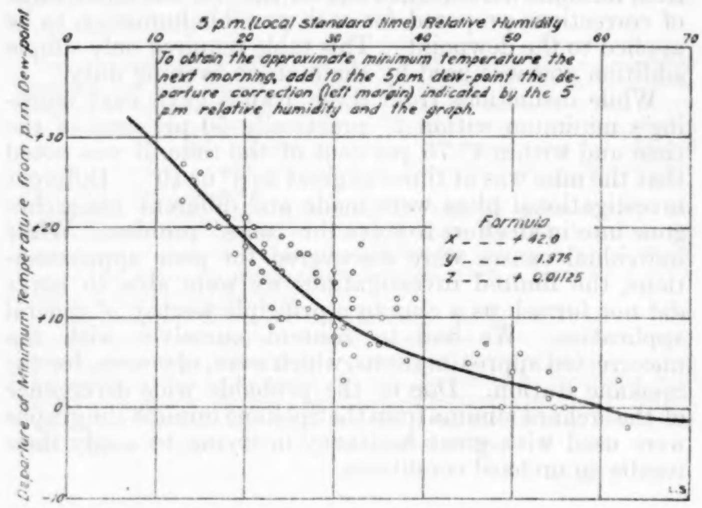


FIG 2.—Minimum-temperature prediction graph for the months of April and May 1917–1921, inclusive, at Spokane, Wash., based on all of the 5 p. m. *partly cloudy* observations for the period.

cloudy nights. The curves are parabolic and based on the equation

$$v = x + by + b^2z.$$

in which b equals the evening relative humidity and v the variation of the minimum temperature the following morning from the 5 p. m. dew point. The values of the unknown quantities, x, y, and z, are shown on the charts.

FORECASTING MINIMUM TEMPERATURES FOR THE CRANBERRY BOGS OF NEW JERSEY.

By George S. Bliss.

[Weather Bureau Office, Philadelphia, Pa., September 19, 1922.]

For many years it has been known that cranberry bogs are very susceptible to late frosts in spring and early frosts in autumn, thus making the growing season much shorter than it is for the surrounding farm lands, and correspondingly increasing the danger to the cranberry crop. However, no definite move was made to study the conditions until the fall of 1905, when special cooperative stations were established on the bogs of Wisconsin, New Jersey, and Massachusetts.

Prof. Henry J. Cox studied the records from the Wisconsin bogs and soon concluded that the stations would need to be manned by trained observers if thoroughly accurate and reliable results were to be assured. Accordingly he assigned assistants from the Chicago station to the bogs in Wisconsin, and spent much of the time during the seasons of 1906 and 1907 in personal supervision of the work. He studied the matter intensively, and determined the values of the several factors, air drainage, radiation, soil temperatures, etc., which combine to produce the temperature conditions that obtain in the Wisconsin bogs. He also correlated these conditions with the weather maps, and gained a vast fund of information for use in forecasting.

In New Jersey the work was continued on a cooperative basis at Whitesbog, near New Lisbon, and in 1909 Professor Garriott made a somewhat cursory study and report of the results.

In the fall of 1917, Mr. C. A. Donnel spent the frost season in the New Jersey bogs, mostly at Whitesbog. He made a careful study of the physical conditions, and his report dealt chiefly with that phase of the problem. The following spring, Mr. J. B. Kincer visited Whitesbog and installed six minimum thermometers and furnished psychrometers for the use of the cooperative observer. The present system of telegraphing reports from the bogs during the frost season was adopted at that time. The temperature records obtained did not add materially to the known meteorological facts.

The writer took the frost records of the Whitesbog station and made a series of map studies for the purpose of correlating conditions as Professor Cox had done for the Wisconsin bogs. These studies revealed the fact that frost may occur on the bogs late in spring or early in autumn with minimum temperatures somewhat higher at surrounding points than are required earlier in spring or later in autumn. For example, during the first half of May frost rarely occurs at Whitesbog until the minimum temperature at Philadelphia is 50° or lower, but early in June there is danger of frost with a Philadelphia minimum of 56° if the radiation conditions are especially good. The reason for this has not been positively determined, but in spring it is believed to be due to the increasing density of the mat of leaves on top of the cranberry vines, which reduces absorption of heat by the soil during the daytime, and also makes a better radiation surface at night. In autumn the reverse process takes place to a certain extent as the leaves die and fall from the vines.

Another condition observed frequently in the map studies was that for a cool period of two or three days duration the lowest bog temperature often followed at a time when a change to rising temperatures had begun in the surrounding country, and the weather map seemed to indicate that the worst was over.

In 1915 Prof. J. Warren Smith became interested in the forecasting of minimum temperatures by means of hygrometric formulæ, which he developed for orchard work at several of the Ohio stations. Later he believed that such formulæ could be used in forecasting for the cranberry bogs with possibly even greater success than obtained in orchard work, since radiation is a more important factor in bog conditions. Research work was reduced to a minimum during and for some time after the war, but in the autumn of 1921 he arranged with the Chief of Bureau for the beginning of a series of observations at Whitesbog, N. J. Mr. Clemmy C. Hamme was assigned as observer to work under the supervision of the writer.

Three locations were selected for the exposure of the instruments, station No. 1 being located on a dike, well out toward the center of a large bog area. The instrument shelter was raised 3 feet above the dike, so that the contained instruments were exposed about 8 feet above the bog, and beyond the immediate effects of radiation. An anemometer was exposed at this station 12 feet above the bog. Station No. 2 was located about a thousand feet from station No. 1, and near the center of the lowest, and consequently the coldest, of all the bogs. Here a minimum thermometer and a 29-hour thermograph were exposed, in the open, about 3 or 4 inches above the top of the vines. Station No. 3 was placed in the woods about 500 feet from the northwestern border of the bog.

Observations were taken from September 21 to October 17, inclusive, under somewhat unfavorable conditions, as radiation was poor the greater portion of the time. There were 10 good, or fairly good, radiation nights. The work was resumed the following spring, observations being taken from May 6 to June 19, inclusive, under more favorable conditions, there being 15 good, or fairly good, radiation nights. The spring series of observations was made by Mr. Charles I. Dague, observer, of the Weather Bureau.

A practical working formula can not be determined from ideal radiation nights only, but must include all conditions which give the grower much concern. Fifteen nights can be selected from the two series of observations which give a formula that is wonderfully accurate when applied to ideal radiation conditions only, but it is not a satisfactory formula for general use. On the 25 dates above mentioned the bog minimum was below 40° F. in each instance, and was considerably below either the dewpoint or the shelter minimum at station No. 1. Some of the nights were partly overcast with high clouds, but each was of such a character as to give a frosty feeling to the air during the early part of the night and thus cause some uneasiness on the part of the grower. Table 1 gives the data which finally determined the selection of the nights mentioned.

TABLE 1.

Night.	8:00 p. m.		8:00 a. m.		Depression of bog minimum.	
	Relative humidity.	Dewpoint.	Shelter minimum.	Bog minimum.	Below dewpoint.	Below shelter minimum.
1921.	Per cent.	°F.	°F.	°F.	°F.	°F.
Sept. 26-27	92	47	41.0	29.8	17.2	11.2
30-Oct. 1	92	55	40.0	29.0	26.0	11.0
Oct. 1-2	84	45	40.0	29.3	15.7	10.7
4-5	85	40	41.0	29.4	10.6	11.6
6-7	76	45	38.0	29.8	15.2	8.2
8-9	80	38	31.4	22.0	16.0	9.6
10-11	83	52	39.0	31.9	20.1	7.1
12-13	77	37	29.8	22.0	15.0	7.8
13-14	89	32	27.7	18.9	13.1	8.8
14-15	96	39	28.8	21.4	17.6	7.4
1922.						
May 8-9	26	27	40.6	31.0	4.0	9.6
10-11	65	54	51.2	39.5	14.5	11.7
12-13	71	43	36.8	28.7	14.3	8.1
15-16	78	52	44.4	33.7	18.3	10.7
16-17	77	45	41.8	31.3	13.7	10.5
19-20	50	44	46.9	38.5	5.5	8.4
23-24	82	54	45.5	38.5	15.5	7.0
24-25	60	46	46.4	35.8	10.2	10.6
27-28	82	45	38.6	28.8	16.2	9.8
28-29	64	42	40.5	30.3	11.7	10.2
29-30	55	49	47.0	34.5	14.5	12.5
30-31	78	55	47.1	37.2	17.8	9.9
June 12-13	38	39	45.3	33.0	6.0	12.3
13-14	81	48	50.9	39.4	8.6	11.5
14-15	73	52	44.6	35.1	16.9	9.5

The median hour was determined for these nights, but gave very erratic and unsatisfactory results when used for computing the minimum temperatures. The straight line formula ($Y=a+bR$) determined by the method of least squares, gives good results in most instances, as shown by Table 2. In this table Y is the depression of the bog minimum below the 8:00 p. m. dewpoint, and R is the 8:00 p. m. relative humidity.

TABLE 2.

Night.	R	Y	R^2	RY	Bog minimum.	Computed minimum.	Error.
1921.	Per cent.	°F.			°F.	°F.	°F.
Sept. 26-27	92	−17	8,464	−1,564	29.8	28.1	−1.7
30-Oct. 1	92	−26	8,464	−2,392	29.0	36.1	+7.1
Oct. 1-2	84	−16	7,056	−1,344	29.3	28.2	−1.1
4-5	85	−11	7,225	−935	29.4	23.0	−6.4
6-7	76	−15	5,776	−1,140	29.8	30.4	+0.6
8-9	80	−16	6,400	−1,280	22.0	22.3	+0.3
10-11	83	−20	6,889	−1,660	31.9	35.5	+3.6
12-13	77	−15	5,929	−1,145	22.0	22.1	+0.1
13-14	89	−13	7,921	−1,157	18.9	13.9	−5.0
14-15	96	−18	9,216	−1,728	21.4	19.0	−2.4
1922.							
May 8-9	26	+4	676	+104	31.0	25.9	−5.1
10-11	65	−14	4,225	−910	39.5	42.4	+2.9
12-13	71	−14	5,041	−994	28.7	29.8	+1.1
15-16	78	−18	6,084	−1,404	33.7	36.9	+3.2
16-17	77	−14	5,929	−1,078	31.3	30.1	−1.2
19-20	50	−6	2,500	−300	38.5	36.4	−2.1
23-24	82	−16	6,724	−1,312	38.5	37.8	−0.7
24-25	60	−10	3,600	−600	35.8	35.7	−0.1
27-28	82	−16	6,724	−1,312	28.8	28.8	0.0
28.29	64	−12	4,086	−768	30.3	30.6	+0.3
29-30	55	−14	3,025	−770	34.5	40.1	+5.6
30-31	78	−18	6,084	−1,404	37.2	39.9	+2.7
June 12-13	38	−6	1,444	−228	33.0	34.7	+1.7
13-14	81	−9	6,561	−729	39.4	32.1	−7.3
14-15	73	−17	5,329	−1,241	35.1	38.2	+3.1
Sum	1834	−347	141,372	−27,291			

b=−0.27
a=5.93

On the night of September 30–October 1 there was seemingly a strong anticyclonic cooling in addition to highly favorable radiation conditions. It was an unusual condition that was not indicated by the weather map. Cloudiness increased during the nights of October 4–5 and June 13–14, lessening radiation so that the temperature did not fall so low as the formula indicated. However, in most instances the results are as accurate as it is possible to determine the dewpoint by means of the ordinary whirling psychrometer.

Following the spring series of observations, Mr. Dague returned to Washington and worked out some very interesting results, based chiefly on the records he had made. The following is quoted from his report:

"Several methods of forecasting the minimum temperatures from the available hygrometric data for radiation nights have been considered. The most successful method is a slight modification of the formula used at Pomona, Calif., by Mr. Floyd D. Young. This formula, as modified, is given below with the corrections to be applied for the varying values of the dewpoint and relative humidity. T, minimum temperature indicated for the following morning; D dewpoint; and H, relative humidity at the evening observation; V, variable quantity depending upon the temperature of the dewpoint; V' variable quantity depending upon the relative humidity.

Weather at time of observation.

Clear or partly cloudy, $T=D-\frac{H-25}{4}+V+V'$.

Cloudy, $T=D-\frac{H-30}{4}+V+V'$.

Dewpoint (° F):	V.	Relative humidity (per cent):	V'.
27	+3	55 to 59	−1
28	+2	60 to 64	−2
29 to 30	+1	65 to 70	−3
31 to 33	0	71 to 72	−4
34 to 35	−1	73 to 88	−5
36 to 37	−2	89 to 93	−6
38 to 39	−3		
40 to 41	−4		
42	−5		
43 to 45	−6		
46 to 47	−7		
48	−8		
49 to 50	−9		
51	−10		

"The application of this modified formula to new data for Whitesbog, N. J., May–June, 1922, for all of the dates with a bog minimum below 40° is given in Table 3 for the 8:00 p. m. observations and in Table 4 for the noon observations.

TABLE 3.—*Observations taken at 8:00 p. m.*

Date.	Dewpoint.	Relative humidity.	Weather, 8:00 p. m.	Forecast minimum.	Actual minimum.	Error.
	°F.	P. cent.		°F.	°F.	°F.
May 8	27	26	Cloudy	31	31	0
12	43	71	Clear	30	29	+1
15	52	78	....do	34	34	0
16	45	77	....do	31	31	0
19	44	50	....do	32	38	−6
23	54	82	....do	35	38	−3
24	46	60	....do	32	36	−4
27	45	82	Pt. cldy	30	29	+1
28	42	64	Clear	29	30	−1
29	49	55	....do	33	34	−1
30	55	78	....do	37	37	0
June 12	39	38	....do	33	33	0
13	48	81	Pt. cldy	31	[1] 39	−8
14	52	73	Cloudy	35	35	0
18	68	89	Pt. cldy	48	49	−1

[1] Sky entirely overcast by 8:45 p. m.

TABLE 4.—*Observations taken at 12:00 noon.*

Date.	Dew-point.	Relative humidity.	Weather, 12:00 noon.	Forecast minimum.	Actual minimum.	Error.
May 8	38	33	Clear	29	31	−2
12	29	20	Pt. cldy	27	29	−2
15	50	42	Cloudy	34	34	0
16	43	32	....do	31	31	0
19	54	48	Pt. cldy	34	38	−4
23	55	43	....do	37	38	−1
24	54	38	Clear	36	36	0
27	48	71	Cloudy	31	29	+2
28	45	43	Pt. cldy	31	30	+1
29	52	37	Clear	35	34	+1
30	53	37	....do	36	37	−1
June 12	48	36	....do	33	33	0
13	36	31	Cloudy	34	[1] 39	−5
14	48	45	....do	30	35	−5
18	72	81	Pt. cldy	49	49	0

[1] Sky entirely overcast by 8:45 p. m.

"In Table 3 the largest error in the forecast minimum temperature, −8°, was due to a rapid clouding up shortly after the evening observation, the sky remaining overcast the remainder of the night. The next largest, −6°, was probably due to the wet condition of the bog, as it had recently been flooded for protection against frost.

"In applying the formula to the noon observations it was necessary to make a change in the dewpoint factors by increasing each factor 4° in order to obtain the forecast minimum temperatures as given in Table 4. With one or two exceptions the minimum temperatures which were forecast show a good agreement with the actual bog minimum, and, as in Table 3, the larger departures are on the safe side.

"Further application of the formula was made to hygrometric data at the regular Weather Bureau station at Philadelphia, Pa., for both the 12:00 noon and the 8:00 p. m. observations, and correlated with the ensuing minimum temperatures at Whitesbog, which is about 40 miles northeast from Philadelphia. Some changes in the formula were necessary before it could be applied to the Philadelphia data. The relative humidity factors were omitted for both the 12:00 noon and 8:00 p. m. observations. For the 12:00 noon observations each of the dewpoint factors was increased 2°. The results are given in Tables 5 and 6.

TABLE 5.—*Application of hygrometric formula, using hygrometric data at Philadelphia, Pa., and bog minimum temperatures at Whitesbog (New Lisbon), N. J. Observations taken at 8:00 p. m.*

Date.	Dew-point.	Relative humidity.	Weather, 8:00 p. m.	Forecast minimum.	Actual minimum.	Error.
	°*F.*	*P. cent.*		°*F.*	°*F.*	°*F.*
May 8	29	23	Clear	30	31	−1
12	39	45	....do	31	29	+2
15	55	71	Pt. cldy	34	34	0
16	42	48	Clear	31	31	0
19	51	54	....do	34	38	−4
23	49	48	....do	34	38	−4
24	42	38	....do	31	36	−5
27	45	71	....do	27	29	−2
28	49	60	....do	31	30	+1
29	52	48	....do	36	34	+2
30	54	58	....do	36	37	−1
June 12	43	36	....do	34	33	+1
13	40	35	Cloudy	35	[1] 39	−4
14	46	48	....do	35	35	0
18	66	74	Pt. cldy	49	49	0

[1] Sky entirely overcast by 8:45 p. m.

TABLE 6.—*Application of hygrometric formula, using hygrometric data at Philadelphia, Pa., and bog minimum temperatures at Whitesbog (New Lisbon), N. J. Observations taken at 12:00 noon.*

Date.	Dew-point.	Relative humidity.	Weather, 12:00 noon.	Forecast minimum.	Actual minimum.	Error.
May 8	37	34	Clear	31	31	0
12	29	23	Cloudy	30	29	+1
15	51	50	....do	34	34	0
16	40	29	Clear	33	31	+2
19	49	48	Pt. cldy	32	38	−6
23	55	49	....do	37	38	−1
24	52	41	Clear	36	36	0
27	51	73	Cloudy	28	29	−1
28	45	45	Clear	31	30	+1
29	45	31	....do	35	34	+1
30	44	30	....do	35	37	−2
June 12	43	28	....do	34	33	+1
13	34	31	Pt. cldy	30	[1] 39	−9
14	54	60	Clear	34	35	−1
18	67	69	Cloudy	45	49	−4

[1] Sky entirely overcast by 8:45 p. m.

"Dot charts were made from the data obtained at Whitesbog during May and June 1922. The relative humidity data, as determined by the 12:00 noon and 8:00 p. m. observations of the dry and wet bulb temperatures, are indicated on the bottom of the diagrams, while the figures entered at the left are the differences between the dewpoint temperature at the noon or evening observations and the ensuing bog minimum temperatures.

"A dot is entered on the chart for each day to agree with the observed relative humidity and the variation of the bog minimum from the dewpoint temperature. The arrangement of the dots on both figures indicates that a parabolic curve is probably the line of best fit. These parabolic curves ($v = x + by + cz$) have been calculated for both charts and the curves drawn. In Figure 2, however, it seems that a straight line would probably fit the arrangement of the dots about as well as the parabolic curve, so the straight line ($y = a + bR$) has also been calculated and superimposed upon this chart. The coefficients from these equations for the lines are indicated on the respective figures.

"The arrangements of the dots about these lines indicates a close relationship between the relative humidity and the variation of the ensuing bog minimum from the dewpoint temperature. It is believed that an even closer relationship will be shown with a larger number of observations.

"A detailed examination of the dewpoint temperatures indicates that a bog minimum temperature low enough to damage the buds on the vines in spring is hardly probable when the dewpoint at the evening observation is above 45°.

"A 29-hour thermograph was exposed at each of the three stations, and a comparison of the traces shows that temperature conditions near the top of the vines change in advance of those of the layers of air higher up; that the minimum is reached sooner near the vines (on theaverage an hour or an hour and a half in advance); on some nights the change being as much as three or four hours in advance.

"From the available records at the Central Office, all bog minimum temperatures under 40° F. occurring at Whitesbog during the spring and fall frost season of 1919, 1920, 1921, and 1922 were selected for correlation

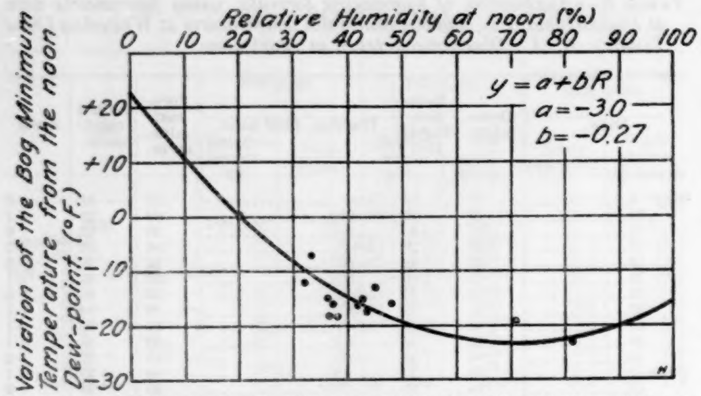


FIG. 1.—Relation between the 12 o'clock noon relative humidity and the variation of the bog minimum temperature during the night from the noon dewpoint. Whitesbog, N. J., May-June, 1922.

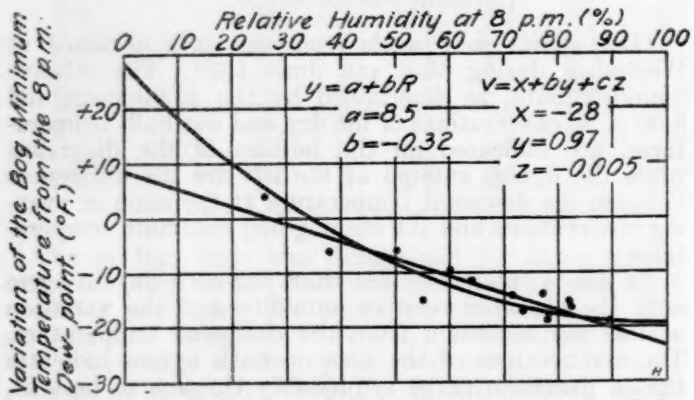


FIG. 2.—Relation between the 8 p. m. relative humidity and the variation of the bog minimum temperature during the night from the 8 p. m. dewpoint. Whitesbog, N. J., May-June, 1922.

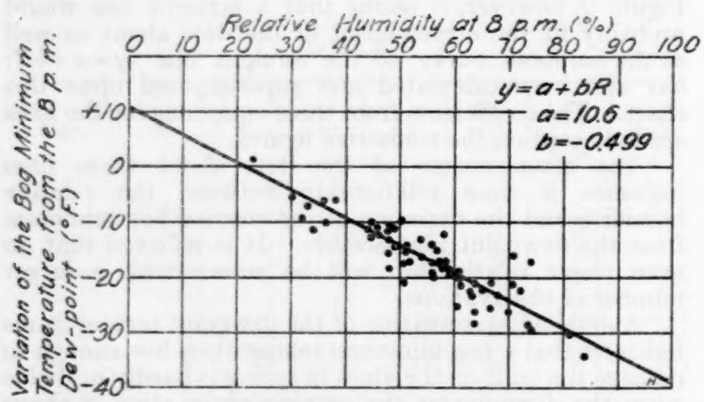


FIG. 3.—Relation between 8 p. m. relative humidity at Philadelphia, Pa., and variation of bog minimum temperature during the night at Whitesbog, N. J., from the 8 p. m. dewpoint at Philadelphia. May, June, September, and October, 1919, 1920, 1921, and 1922.

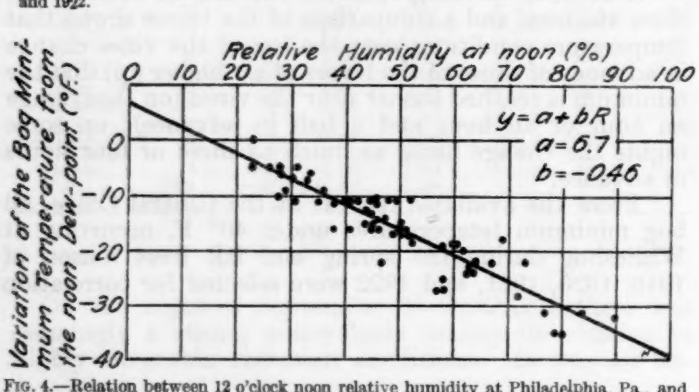


FIG. 4.—Relation between 12 o'clock noon relative humidity at Philadelphia, Pa., and variation of bog minimum temperature during the night at Whitesbog, N. J., from the 12 o'clock noon dewpoint at Philadelphia. May, June, September, and October, 1919, 1920, 1921, and 1922.

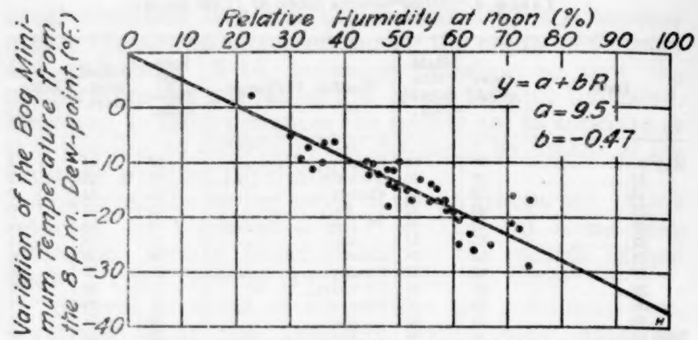


FIG. 5.—Relation between 8 p. m. relative humidity at Philadelphia, Pa., and variation of bog minimum temperature during the night at Whitesbog, N. J., from the 8 p. m. dewpoint at Philadelphia. May and June, 1919, 1920, 1921, and 1922.

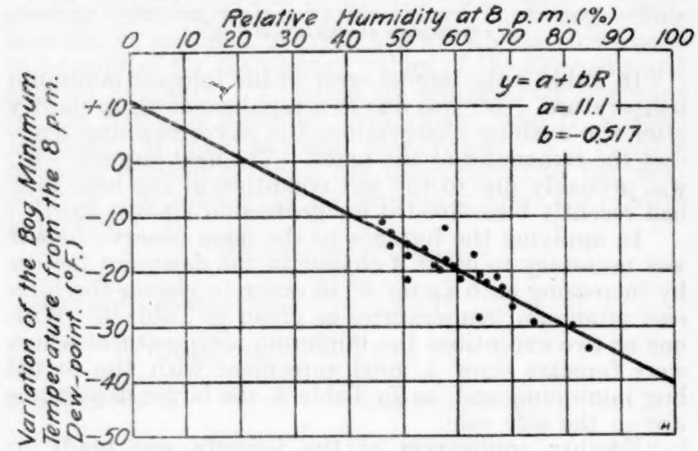


FIG. 6.—Relation between 8 p. m. relative humidity at Philadelphia, Pa., and variation of bog minimum temperature during the night at Whitesbog, N. J., from the 8 p. m. dewpoint at Philadelphia. September and October, 1919, 1920, 1921, and 1922.

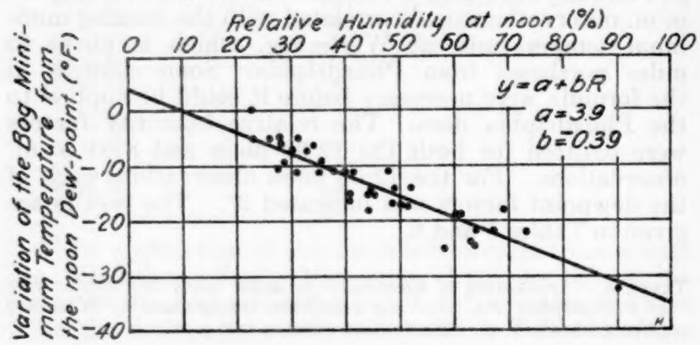


FIG. 7.—Relation between 12 o'clock noon relative humidity at Philadelphia, Pa., and variation of the bog minimum temperature during the night at Whitesbog, N. J., from the 12 o'clock noon dewpoint at Philadelphia, May and June, 1919, 1920, 1921, and 1922.

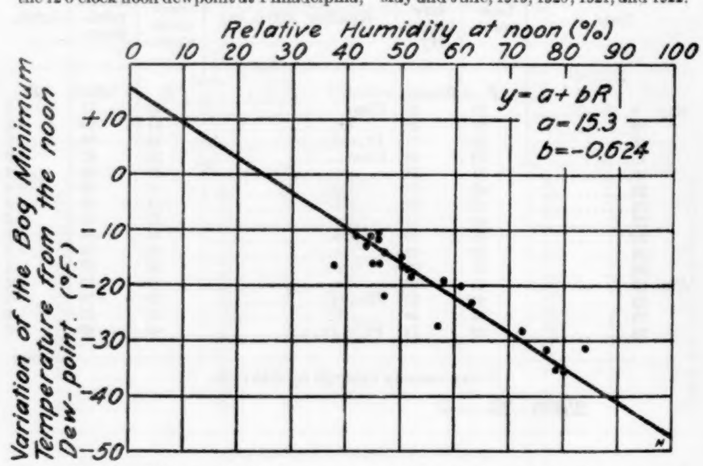


FIG. 8.—Relation between 12 o'clock noon relative humidityat Philadelphia, Pa., and variation of the bog minimum temperature during the following night at Whitesbog, N. J., from the 12 o'clock noon dewpoint at Philadelphia. September and October, 1919, 1920, 1921, and 1922.

with hygrometric data obtained at the regular observations of the Weather Bureau Office at Philadelphia. By means of the barograph and thermograph trace sheets from Philadelphia and the corresponding weather maps, the bog minimum temperatures on those days which clearly showed that they were not of radiation origin were eliminated. Thus the writer could feel quite sure he was using data representative, or fairly so, of radiation conditions. In all, 61 observations were used.

"Dot charts were made, using bog minimum temperature data for Whitesbog and hygrometric data for Philadelphia, following the same plan for plotting these data as was used in Figures 1 and 2. These charts are shown in Figures 3 to 8, inclusive.

"From the arrangement of the dots on each chart, a straight line appears to be the best fit and the equation $(y=a+bR)$ has been calculated, the coefficients of which have been entered on the respective charts.

TABLE 7.—*Distribution of departures of forecast bog minimum temperatures made from hygrometric data at Philadelphia, Pa., from actual bog minimum temperatures at Whitesbog (New Lisbon) N. J., using Figures 3 to 8, inclusive.*

Departures.	Fig. 3.	Fig. 4.	Fig. 5.	Fig. 6.	Figs. 5 and 6 combined.	Fig. 7.	Fig. 8.	Figs. 7 and 8. combined.
0	16	9	8	4	12	5	5	10
±1	9	22	6	12	18	17	5	22
±2	16	10	8	3	11	6	7	13
±3	7	7	10	0	10	4	2	6
±4	4	4	1	0	1	3	0	3
±5	4	5	3	1	4	2	0	2
±6	2	0	1	2	3	1	2	3
±7	1	3	0	1	1	0	1	1
±8	0	1	1	0	1	0	1	1
±9	2	0	0	0	0	0	0	0
0	16	9	8	4	12	5	5	10
+	22	25	13	9	22	14	8	22
−	23	27	17	10	27	19	10	29
Total	61	61	38	23	61	38	23	61

"Figures 3 and 4 show the data charted for the total number of 12:00 noon and 8:00 p. m. observations for both the spring and fall seasons. Figures 5 to 8, inclusive, were charted to ascertain if the accuracy of the bog minimum temperatures forecast could be increased if the spring and fall seasons were separately considered for both the noon and evening data. The accuracy was slightly increased but not so much as was hoped for, although some of the largest departures were eliminated. Table 7 gives in summarized form the remarkable results obtained.

"The data in Table 7 show that the forecast bog minimum temperatures for Whitesbog, based on hygrometric data at Philadelphia, were within 2° F. of the actual bog minimum temperatures from 65 to 75 per cent of the time, while departures in excess of 4° were very few indeed."

CONCLUSION.

(1) In conclusion it may be said that for the best possible results in forecasting minimum temperatures for cranberry bogs a good hygrometric formula is necessary for use with the weather map. (2) That when the weather map indicates the radiation conditions to be good, the hygrometric formula will give a closer and more uniformly consistent estimate of the probable bog minimum temperatures than it is possible to obtain otherwise. (3) That a hygrometric formula, correlated between the bog minima and data from a near-by Weather Bureau station, will give fairly accurate and reliable results, and is a valuable aid to the forecaster. (4) That a hygrometric formula adapted to a given locality, if intelligently and accurately applied by the grower, would be a fairly reliable safeguard without other information. (5) That in the latter case, when general radiations were not so good as they appeared to be locally, the formula might give too low a temperature and cause the grower to flood the bogs unnecessarily and at some loss, which the aid of the weather map would in most cases avoid. (6) That under ideal radiation conditions the error of a well-calculated hygrometric formula seems to be no larger than the personal equation in obtaining the data. (7) That the data for at least 50 good, or fairly good, radiation nights should be used in calculating the formula.

A SIMPLE GEOMETRIC DERIVATION OF THE LAWS OF REFRACTION OF LIGHT INCLINED TO A PRINCIPAL PLANE OF A PRISM.

By W. J. HUMPHREYS.

[Weather Bureau, Washington, D. C., November 23, 1922.]

In the theory of halos, as also in any general discussion of the action of refracting prisms on light, it is necessary to consider the course of rays inclined at various angles to a principal plane—that is, a plane normal to both the face through which the light enters the prism and the face through which it leaves the prism, or, what comes to the same thing, normal to the intersection of these two faces.

This problem was first discussed fully by the French astronomer Auguste Bravais, and the laws found (often called Bravais' laws of refraction) used in his classical memoir on halos.[1] They have also been variously derived by other writers, most recently by Terpstra,[2] and, with mathematical elegance and dispatch, by Laville.[3] However, none, presumably, of these various derivations, some of which are tedious to follow, is readily available to the average reader of the REVIEW. It may be worth while, therefore, to give those naturally most interested in halos a straightforward discussion of the refraction of light rays inclined to a principal plane.

In what follows it will be necessary to remember the well-known facts:

1. The angle of incidence is the angle between the incident ray and the normal to the surface at the point of incidence.

2. The angle of refraction is the angle between the refracted ray and the normal (within the prism) to the surface at the point of refraction.

3. The plane of the incident and refracted rays is normal to the incident surface at the point of incidence. Similarly, the plane of the refracted and exit rays is normal to the exit surface at the point of exit.

4. If i is the angle of incidence and r the angle of refraction, then $\sin i = \mu \sin r$, where μ, called the index of refraction, is the ratio of the velocity of light in the surrounding medium, air, say, to its velocity within the prism.

Remembering these facts, let ABC, Figure 1, be a principal plane of a prism; let DEF be the plane, perpen-

[1] Journal de l'Ecole Royale Polytechnique, 18, 1847.
[2] Zeit. f. den phys. und chem. Unterricht, p. 80, March, 1922.
[3] Journal de Phys. et le Radium, 2, p. 62, 1921.

dicular to the face of incidence, determined by the incident and interior portions of a ray entering the prism at O and leaving it at O'; let GH be the intersection of these two planes: and let ON be normal to the face of incidence at O. Draw OM normal to the principal plane, and connect M with L and K, the points on the intersection GH determined by the interior ray and the incident ray extended, respectively.

Since GH is the intersection of two planes both of which are normal to the incident face, it also is normal to that face and, therefore, parallel to ON. Hence the

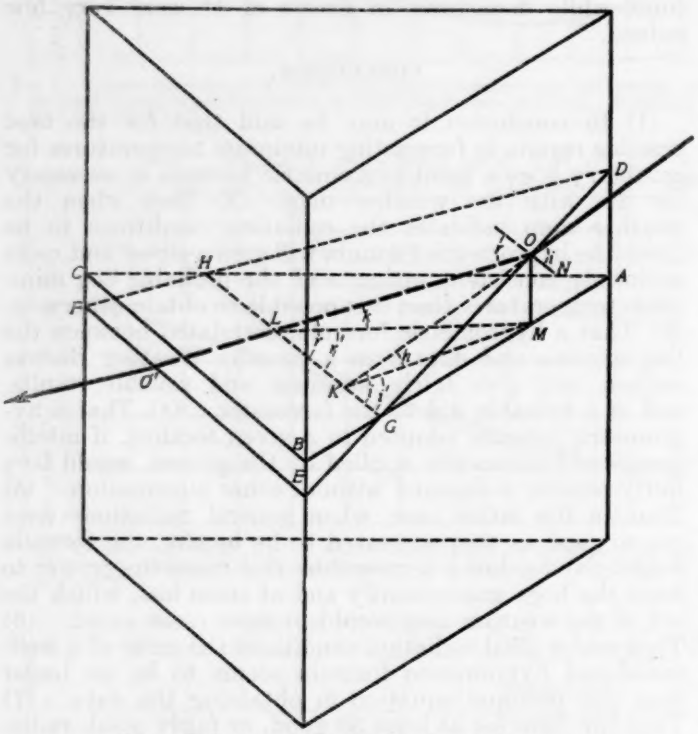


FIG. 1.—Path of a ray inclined to the principal plane.

angle OKG is equal to the angle of incidence, i, and the angle OLG equal to the angle of refraction, r.

Clearly, then, since

$$\sin i = \mu \sin r,$$

if, in length, $KO = 1$, it follows that

$$LO = \mu,$$

and $\sin h = \mu \sin k$, in which h and k are the angles between the principal plane and the incident and interior rays respectively.

The angles between the principal plane and the incident and interior rays, respectively, are connected by the law of sines.

Similarly,

$$\sin h' = \mu \sin k',$$

in which h' and k' are the angles between the principal plane and the exit and interior rays, respectively. But, obviously,

$$k' = k, \text{ hence } h' = h.$$

The incident and the exit rays are equally inclined to the principal plane.

Finally, if i' and r' are the projections of i and r, respectively, onto the principal plane, then

$$\mu \cos k \sin r' = \cos h \sin i',$$

or

$$\frac{\sin i'}{\sin r'} = \mu' = \mu \frac{\cos k}{\cos h}.$$

A ray inclined to the principal plane of a prism is so bent that its projection on this plane is the course a ray in this plane would take if the refractive index of the medium were increased by the ratio of the cosines of the angles between this plane and the internal and the incident (or exit) rays, respectively.

RARE HALO OF ABNORMAL RADIUS.

By A. F. PIPPO, Observer.

[Madison, Wis., May 12, 1922.]

On April 27, 1922, there was observed at Madison, Wis. (lat. 43° 05′ N, long. 89° 23′ W.), a very distinct form of solar halo of abnormal radius occurring simultaneously with a very brilliant halo of 22°. Halos of abnormal radius of less than 10° have been recorded probably less than a half dozen times in the United States, references to those on record in the MONTHLY WEATHER REVIEW being **43**:213, **43**:592, **47**:120, **47**:340.

The rare occurrence of such halos warrants special record being made thereof. Photographs of the halo in a black convex mirror were made. These failed due to lack of filters. Approximate theodolite readings establish the radius at about 8° 12′.

The appearance of the halo was first noted by the writer at 2:15 p. m., 90th meridian time. The sky was nearly overcast with a thin, whitish cirro-stratus veil (west) except where patches of cirro-cumuli appeared apparently at a lower level (WNW.). The smaller halo appeared as a distinct white ring of not more than 1° in width, the accompanying 22° halo being brighter than usual.

There was little change in the conditions of the phenomenon until 2:50 p. m., when for a short time it attained its greatest brilliancy. The 22° halo showed greater coloring at its upper and lower parts, appearing slightly elliptical. However, no measurements to indicate the distortion were made. The 8° halo continued as a whitish ring except that in the upper righthand quadrant could be seen the reddish blue tinge. Sun's altitude 47° 18′ at approximately 2:50 p. m. The phenomenon was easily visible until 3:10 p. m., when it disappeared behind a dark patch of cirro-cumulus. The 22° halo of average brightness was recorded at 7:30 a. m. and again at 6:15 p. m.

CERTAIN UNUSUAL HALOS.

By W. J. HUMPHREYS.

[Weather Bureau, Washington, D. C., November 23, 1922.]

Satisfactory theories exist for all, or nearly all, the more common halos. Several of the rarer halos, however, are not so well understood. It is the purpose of this article to supply, in part, this lacking information.

Halo of 90°.—Occasionally a faint halo, sometimes called the "Halo of Hevelius," is seen at about 90° from the sun. Several explanations of this halo have been suggested, but none is satisfactory.

In seeking to explain this or any other halo, it is essential that our attention be given first to simple forms of discrete ice crystals, because there is little or no evidence that any special grouping of crystals ever occurs in sufficient abundance and predominance to produce a halo of any kind.

Now, only two kinds of small ice crystals are known to occur naturally, namely, (*a*) hexagonal columns, long (needles) or short (tablets), with flat bases perpendicular to the sides, and (*b*) hexagonal abutting pyramids, truncated or not, and with or without an intervening hexagonal column.

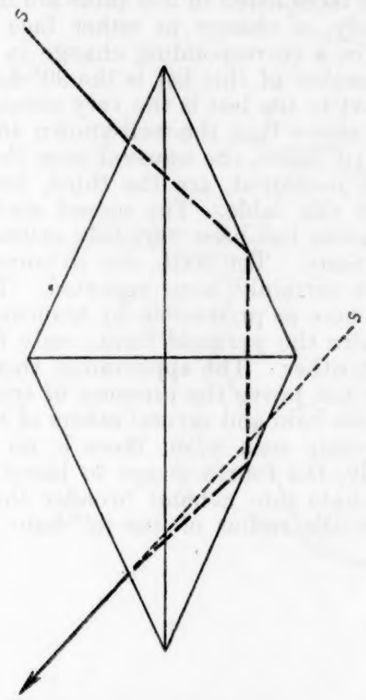


FIG. 1.—Path of a ray through a pyramidal prism giving a 90°-halo.

The 90°-halo seems to be owing to the presence of randomly directed bipyramidal crystals whose faces are inclined 24° 51′, or thereabouts, to the longitudinal axis.

Apparently no exact measurements of pyramidal ice crystals have ever been made.[1] However, by X-ray analysis it has been shown [2] that the oxygen atoms of an ice crystal are arranged in hexagonal patterns, and so spaced that the ratio of the longitudinal to the lateral axes is very close to 1.62.

Hence, from the laws of crystallography, the ratio of the height of the pyramidal end of an ice crystal to the inner radius of its base, a lateral axis, must also be 1.62, or some multiple or submultiple thereof expressible in either a small whole number or a fraction whose numerator and denominator both are small whole numbers.

If, then, we multiply 1.62 by 4/3, a factor entirely allowable, we obtain a pyramid whose sides are inclined 24° 51′ to the longitudinal axis; and since this value satisfies both the 90°-halo, and also several other halos of unusual radii, as explained below, it will be provisionally accepted as a value that actually occurs in nature.

Light from any source S, Figure 1, entering a face of such a crystal (truncated or pointed, and with or without an intervening hexagonal column), in or near a plane determined by the longitudinal axis and a normal to that face from this axis, will, over a wide range (42° 06′) of the angle of incidence, undergo two internal total reflections and pass out the corresponding face of the abutting pyramid in such direction that an observer at O will see the image S_1 very nearly 90° from the source; the total range being, for light of refractive index 1.31, from 89° 28′ where the concentation is greatest to 88° 02′ where it is least. Light outside this range is relatively too faint to be considered, being enfeebled by at least one reflection that is not total. Minimum refraction, hence, in this case, maximum deviation (turning of the ray by reflection minus its turning by refraction) and maximum concentration, occurs when that portion of the internal ray that lies between the points of reflection is parallel to the longitudinal axis. This, as above stated, puts the brighter edge of the halo at nearly 90° from the sun or moon. Clearly, too, the red of this halo, contrary to rule, is on the side away from, and not the side nearest to, the parent luminary, and still nearer 90° therefrom than the above angular distance, 89° 28′, corresponding to greenish yellow light, though always, perhaps, too faint to arouse a distinct color sensation.

Halos of unusual radii.—In addition to the halo of 22° radius, due to randomly directed 60° refracting angles, the halo of 46° radius, due to randomly directed 90° refracting angles, and the 90°-halo, explained above, several other halos concentric about the sun or moon are occasionally seen. The radii of these are, roughly, 8°, 17°, 19°, and, perhaps, 32°. The last of these values is based on various crude estimates ranging from about 28° to 33°, or more; the other three have been measured, and probably are correct to within half a degree. Piippo,[3] using a theodolite, obtained 8° 12′ as the radius of a certain small but well-defined halo. He reports, in addition, only the 22°-halo. Andrus[4] estimated the radius of the inner halo to be 8°–9° and that of the outer one to be 28°–29°. A crude sighting device that gave him 22° 50′ for the radius of the 22° halo, gave for the other two 17°–18° and 18°–19°, respectively.

All these halos of unusual radii, 8°, 17°, 19°, and 32° (?), doubtless are due to randomly directed pyramidal crystals; whether truncated or pointed, and with or without columns between the pyramidal ends. Such a pointed, bipyramidal crystal, with an intervening hexagonal column (a well-known type) is represented by

[1] Dobrowolski, *Arkiv för Kemi, mineralogi och geologi*, v. 6, No. 7, p. 44, 1916.
[2] A. St. John, *Proc. Nat. Acad. Sciences*, 4, p. 193, 1918; D. M. Dennison, *Phys. Rev.*, 17, p. 20, 1921; W. H. Bragg, *Proc. Phys. Soc., Lond.*, 34, p. 98, 1922.

[3] See this REVIEW, p. 534.
[4] MO. WEATHER REV., May, 1915, 43:213.

Figure 2. Light obviously can pass through such a crystal in various directions. Those courses that give refraction, and hence produce halos, are listed in the following table, in which the numerical values correspond to an inclination of 24° 51′ of a pyramidal face to the

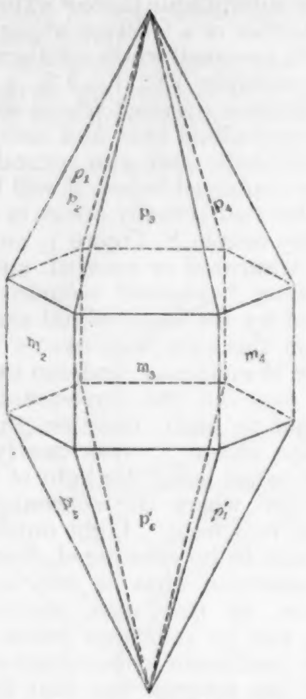


FIG. 2.—Pyramidal ice crystal giving halos of unusual radii.

longitudinal axis, the value adopted above in the discussion of the 90°-halo.

In this table the meanings are: *incident face,* that face of the crystal through which the ray in question passes in; *exit face,* that face of the crystal through which the given ray passes out; *refraction angle,* the dihedral angle between the incidence and exit faces, extended; *minimum deviation,* the least difference in direction between the incident and exit branches of any single ray—the deviation corresponding to maximum light, hence to the angular radius of a particular halo.

Circular halos about sun or moon, by pyramidal crystals, whose faces are inclined 24° 51′ to longitudinal axis.

Incidence face.	Exit face.	Refraction angle.	Minimum deviation.
p_1	p_4	49° 42′	17° 06′
p_1	p_3	76° 24′	31° 49′
p_1	m_4	24° 51′	7° 54′
p_1	m_3	63° 01′	23° 24′
p_1	p'_6	53° 58′	18° 58′
c	p′	65° 09′	24° 34′
c	m	90°	45° 44′
m_1	m_3	60°	21° 50′
p_1	p'_4	[1] 130° 18	[2] 89° 28

m, face of hexagonal column; p, face of one pyramid; p′, face of companion pyramid; c, truncate face, normal to longitudinal axis.

[1] Not really a refraction angle, but the crystal angle between the incident and exit rays.

[2] Maximum total deviation, corresponding to minimum refraction.

The pairs of faces listed in this table are merely typical since, obviously, a change in either face of any pair merely requires a corresponding change in the other.

The last member of this list is the 90°-halo explained above; the next to the last is the very common 22°-halo; and the next above that the well-known 46°-halo. The 8°-, 17°-, and 19°-halos, the unusual ones that have been tolerably well measured, are the third, first, and fifth, repectively, of this table. The second may well be the halo whose radius has been variously estimated at from 28° to 33° or more. The sixth, due to truncated bipyramids, has not certainly been reported, The 46°-halo, though listed here as producible by truncated pyramids, does not require the pyramid form—only faces at right angles to each other. The appearance, therefore, of the 46°-halo does not prove the presence of truncated pyramids; hence this halo and several others of the table may be simultaneously seen when there is no trace of the sixth. Finally, the fourth is apt to blend more or less with the 22°-halo into a band broader than usual and thereby cause the radius of the 32°-halo to be underestimated.

ON THE LOWER OBLIQUE ARCS OF THE ANTHELION.

By EDGAR W. WOOLARD.

[Weather Bureau, Washington, D. C., November 18, 1922.]

About the middle of May, 1915, there was observed at Haverford, Pa., by Prof. Frederick Palmer, jr., of Haverford College, a halo display which included the rare arcs that have been designated by Hastings[1] the "Lower oblique arcs passing through the anthelion." Professor Palmer's description of this feature, contained in a letter, is as follows:

"The curved white streamers, or wings, which sprang from this mock-sun [anthelion] were less brilliant, more diffuse, and not so broad as the parhelic circle. They did not project within the parhelic circle, but appeared to form a cusp with its apex at the center of the mock-sun. The wings did not end abruptly, but appeared to vanish diffusely into the background. There was, however, a distinct inward curvature, suggesting that, if complete, the wings might form a similar cusp on the opposite side of the sun, or perhaps join in an arc running tangent to the 22° halo." The time was about 11 a. m., making the sun's altitude closely 65°; the 22° halo, parhelic circle, anthelion, and a portion of the 46° halo were also present.

Hastings explains these lower oblique arcs as due to light which, at a high altitude of the sun, falls upon the upper sloping face, toward the sun, of a hexagonal columnar ice crystal in its position of maximum stability—viz, with two lateral faces horizontal—and emerges from the lower horizontal face after having been internally reflected by a base; the course of the light is shown in Figure 1. He does not indicate any method by which the resulting arcs may be computed, but a well-known general method in geometrical optics[2] may readily be adapted to the computation of the luminous arcs produced by the rotation of any dihedral refracting angle, with a *horizontal edge*, about a vertical axis; the following is perhaps a more practical solution of this problem than the form given by Bravais:[3]

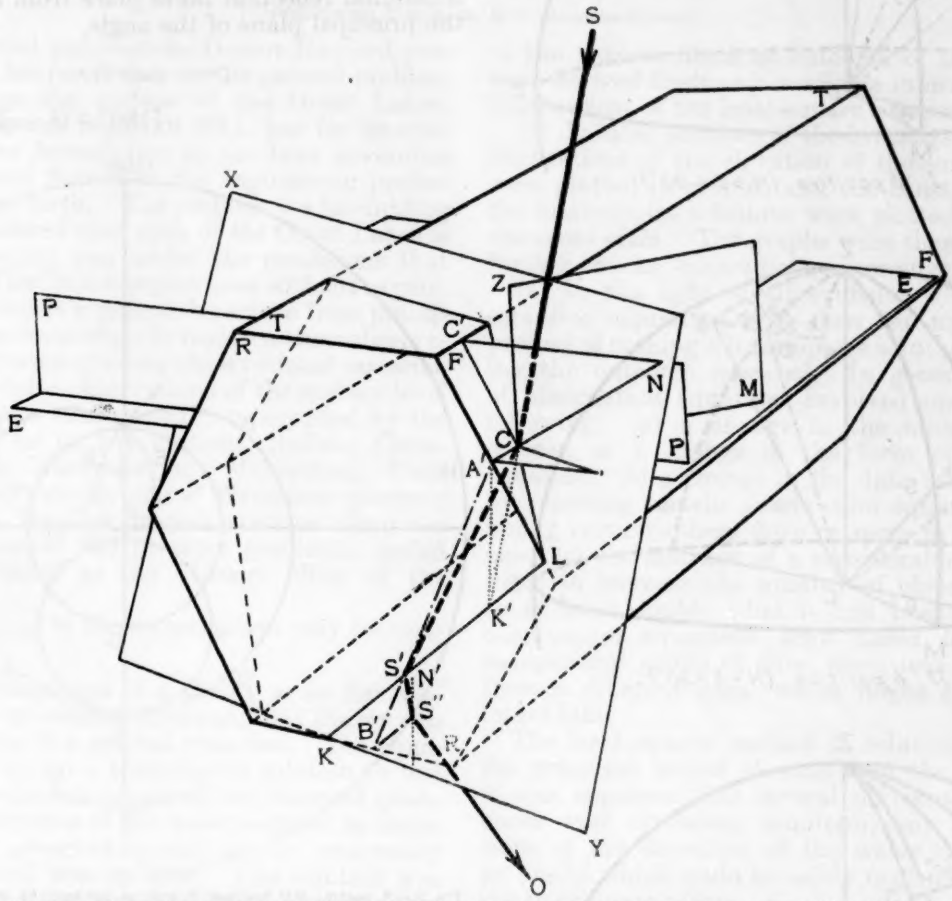


FIG. 1.—*TT*, upper horizontal lateral face; *FF*, sloping lateral face turned toward sun; *S*, sun; *SC*, incident ray; *CN*, normal to *FF* at *C*, the point of incidence; *SCN*, angle of incidence; *CS'*, refracted (internal) ray; *XY*, plane containing *SC*, *CS'*, and *CN*; *RR*, base of crystal, and principal plane of the dihedral refracting angle; *KL*, intersection of *XY* with *RR*; *CK'*, extension of *SC* to *KL*; *A'S'*, projection of *CS'* on *RR*; *A'K'*, projection of *CK'* on *RR*. *KL* is normal to *FF*, hence parallel to *CN*, and therefore $\sin CK'L = \mu \sin CS'L$; $A'K'C = h$. *PP*, vertical plane through *C* parallel to *RR*; *EE*, horizontal plane through *C*; *CZ*, vertical through *C*; *ZM*, vertical plane through *SC*; *SCM*, altitude of sun; $PCM = \theta$; *C'CZ*, 30°. *S'*, point of internal reflection; *S''*, point of exit; *S''O*, emergent ray; *A'B'*, projection of internal ray on *RR*; *S''N'*, normal at point of exit.

The course of the light in Figure 1 is derived through a direct application of Bravais' Laws of Refraction[4]; if we now extend the lines and planes of Figure 1 to the celestial sphere, parallel lines intersect the sphere in the same point, parallel planes in the same great circle, observer and crystal become a single point located at the center of the sphere, and we obtain Figure 2.

Let H be the altitude of the sun; θ the angle between the principal plane of the refracting angle and the plane

[1] Hastings, C. S.: A General Theory of Halos. Mo. WEATHER REV., 48; 329, 1920.

[2] See, *e. g.*, Uhler, H. S.: On the Deviation Produced by Prisms. *Amer. Jour. Sci.* (4) 35; 390, 1913.

[3] On pp. 225–233 of his *Mémoire sur les Halos*, Paris, 1847.

[4] *See* Humphreys, W. J.: A simple geometric derivation of the laws of refraction of light inclined to a principal plane of a prism. This REVIEW, p. 533. It will be seen that Figure 1 of the present article is obtained by merely taking Doctor Humphreys' diagram and fitting it into the proper position in the ice crystal.

of the solar vertical; h the inclination of the incident ray to the principal plane; and H' the inclination, to the plane of the horizon, of the projection of the incident ray upon the principal plane. The general formulæ then are:

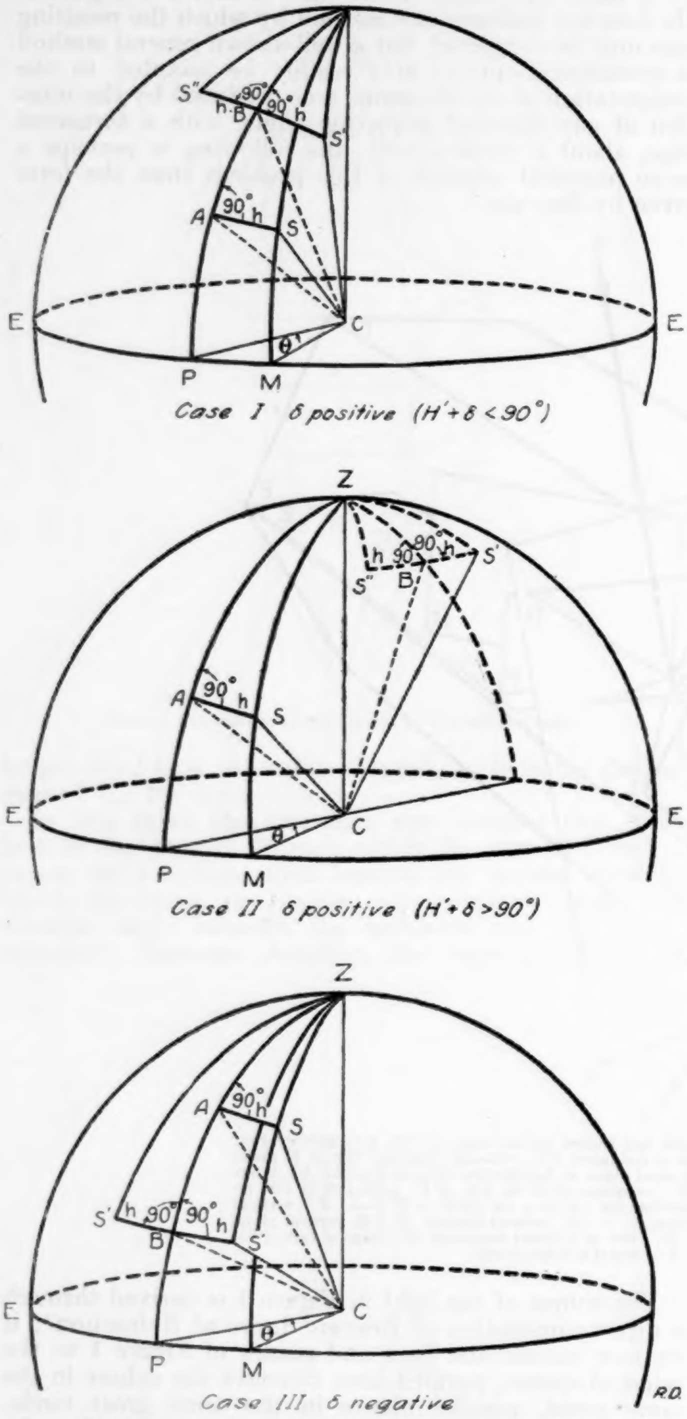


FIG. 2.—C, observer; EE, rational horizon; Z, zenith; S, sun; SC, incident ray; $ZAPC$, principal plane; $ZSMC$, plane of solar vertical; AC, projection of incident ray upon principal plane; CB, backward extension of projection of emergent ray; CS', backward extension of emergent (refracted) ray in the absence of internal reflection; S', image, in the absence of internal reflection; CS'', backward extension of emergent ray after internal reflection from a principal plane; S'', image, in the case of internal reflection from a principal plane; $AB=\delta$.

$$\sin\theta=\sin h \sec H, \qquad 0°\leqq\theta\leqq 90°,$$

$$\sin H'=\sin H \sec h,$$

$$\cos d=\cos h \sin (H'+\delta), \qquad 0°\leqq (H'+\delta)\leqq 180°,$$

in which δ is the deviation of the projected ray (considered positive if the backward extension of the emergent ray lies above the incident ray), and d is the zenith distance of the image. If ζ be the azimuth of the image, referred to the solar vertical as origin, and if we put

$$\sin\omega=\sin h \csc d,$$

then when internal reflection does not occur

$$\zeta=\omega-\theta, \qquad (H'+\delta)<90°$$

$$\zeta=180°-(\omega+\theta), \qquad (H'+\delta)>90°;$$

if internal reflection takes place from a plane parallel to the principal plane of the angle,

$$\zeta=-(\omega+\theta), \qquad (H'+\delta)<90°$$

$$\zeta=-[180°+(\theta-\omega], \qquad (H'+\delta)>90°;$$

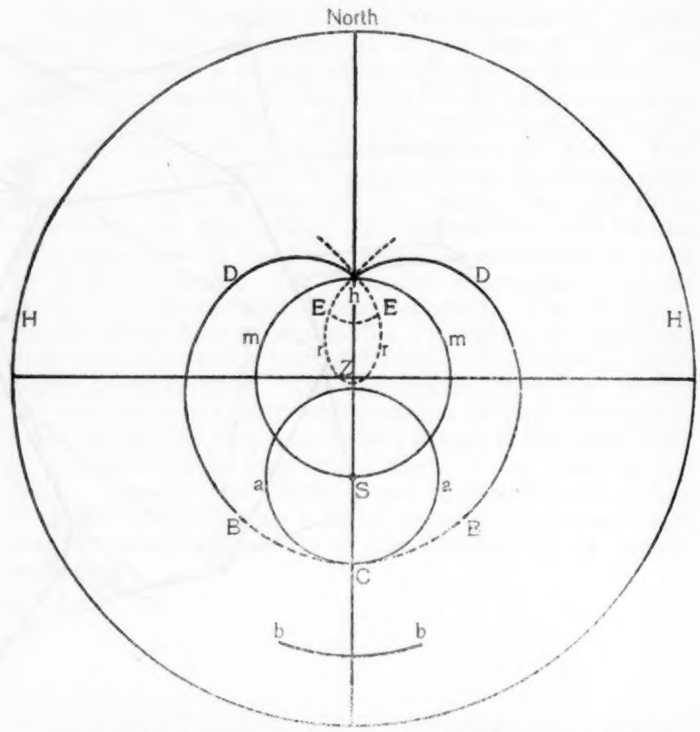


FIG. 3.—Z, zenith; HH, horizon; S, sun; aa, 22° halo; bb, 46° halo; mm, parhelic circle; h, anthelion; DBC, lower oblique arcs passing through the anthelion; rr, upper oblique arcs passing through the anthelion; the portions Eh are common to both the upper and the lower oblique arcs of the anthelion.

negative azimuths are measured in the direction of the principal plane. The reflection will be total if

$$0°\leqq h\leqq 57° 48'.$$

In the case of ice crystals (without pyramidal caps, we have dihedral refracting angles of 60° and 90°; it is necessary to take into account only orientations which (1) correspond to minimum deviation, or (2) in which two lateral faces of the crystal are horizontal. In the above equations, optical considerations frequently prevent the independent variables from attaining their geometrical limits.

The writer has previously [5] applied the above method to the case in which light is incident on the top horizontal faces of crystals in the equilibrium position; light

[5] Woolard, Edgar W.: The Boulder Halo of Jan. 10, 1918. MO. WEATHER REV., 48: 331–332, 1920; *cf.* Humphreys, W. J.: *Physics of the Air*, Philadelphia, 1920, pp. 524–527.

incident on the top *sloping* faces produces, after basal reflection, the lower oblique arcs; in the latter case, the general formulæ give

$$\cos d = \cos h \cos i',$$

where i', the second "angle of incidence" of the projected ray, is easily found from the Laws of Refraction.[6] Hastings fails to bring out in his paper the fact that *both* the top sloping faces are required to produce the complete arcs; furthermore, he ascribes their inner extension from the anthelion, when seen, to light entering the top horizontal face only, whereas in reality the sloping face away from the sun also contributes to this.

Figure 3, fully explained in the legend, shows the complete theoretical halo, calculated for $H=65°$, corresponding to the observation of Professor Palmer; the *full* lines show the features *actually observed*, as indicated in a sketch accompanying his letter.

[6] Humphreys, W. J.: *Physics of the Air*, pp. 483, 488.

HAYFORD ON EFFECTS OF WIND AND OF BAROMETRIC PRESSURE ON THE GREAT LAKES.[1]

By ALFRED J. HENRY.

[Weather Bureau, Washington, D. C., November 24, 1922.]

In the above-named publication, Doctor Hayford presents an account of his researches on the general problem of evaporation from the surface of the Great Lakes. The research, which was begun in 1911, has for its ultimate object a better formulation of the laws governing the amount of stream flow than the engineering profession is now able to set forth. The problem is a fascinating one when it is considered that each of the Great Lakes is used as an evaporating pan under the conditions that obtain in nature. That it is complex goes without saying.

Doctor Hayford makes a radical departure from practically all known precedents when he makes no new observations but is content to use existing observational material, viz, the hourly and daily observations of the surface level of Lake Erie and Lake Michigan-Huron, supplied by the U. S. Lake Survey for its five stations, Buffalo, Cleveland, Harbor Beach, Mackinaw, and Milwaukee. Data of wind direction and velocity and of barometric pressure were obtained from Weather Bureau stations along the lakes, or, in the case of the pressure gradients, scaled from the forecast charts at the Chicago office of the Weather Bureau.

The method followed in the investigation may be summarized as follows:

(1) After the development of a theory as to the relations of the various quantities involved, that theory was expressed in the form of a general equation. The equations were then set up for a least-square solution to test the theory. Each equation expressed an observed quantity, a change in elevation of the water surface, in terms of other known or observed quantities, in conformity with the theory which was on trial. The solution was then made by the least-square method of computation. Out of these solutions arose a set of computed values of the unknowns assumed to be constants, which were supposed to express the relations between the observed quantities and a set of residuals which are the discrepancies between the tentative theory and the observed facts.

(2) The outcome of the least-square solution was then studied in the light of all available internal and external evidence. As the theory expressed in the observation equations of such a solution approaches more closely to perfection, the computed probable errors are smaller, the residuals, as a rule, are smaller, and the distribution of the residuals as to sign and magnitude follow the laws of accidental errors more closely. These tests furnished the main portion of the internal evidence. The external evidence was derived mainly (*a*) from comparisons of the outcome of the solution with that from other solutions already made, (*b*) from a study of apparently abnormal residuals, and (*c*) from general checks on the reliability of the various items of outcome of the solution which were derived from any available information which was independent of the least-square solutions.

(3) In later portions of the investigation, the observed fluctuations of the elevation of the surface of the water were plotted in graphs, and the constants derived from the least-square solutions were plotted, superposed over the same scale. The graphs were then studied to secure further checks, contradictions, or suggestions.

(4) In the light of all evidence a new series of observation equations was then set up and the whole process of making a least-square solution and then studying the outcome repeated. In general, each new set of observation equations involved one or more of the following: (*a*) a change in the tentative theory, expressed as a change in the form of the observation equation; (*b*) a change in the data used, brought about by rejecting certain observation equations, or by combining certain others (two or more in a group) to form one; (*c*) the addition of a considerable amount of data, so as to increase the number of observation equations to at least double what it had been; or (*d*) the new observation equations were based upon an entirely independent group of data, elevations of water surfaces from a different gage, which might even be on a different lake.

The least-square method of solution was adopted as the principal means of attack on the problem because it was apparent that several different factors or influences were operating simultaneously to cause fluctuations of the elevation of the water surface at a gage, no one of which could be safely neglected while attempting to evaluate others.

The outcome of the investigations is stated in the following numbered paragraphs:

(1) Reasonably accurate numerical expressions have been obtained for the effects of barometric pressures on the elevation of the water surface at the five stations, Buffalo, Cleveland, Milwaukee, Mackinaw, and Harbor Beach, on Lake Erie and on Lake Michigan-Huron. With these expressions, one may, from the distribution of barometric pressures ordinarily shown on the forecast maps of the Weather Bureau, compute the disturbances in elevation of the water surface thereby produced at the stations named.

(2) The general method has been developed by which such a numerical expression for the barometric effect at any station on any body of water may be derived from observations of the water elevation at that station and the forecast maps for the same period.

(3) A general expression, including the necessary numerical constant, has been obtained for the effect of the winds, of any given velocity and direction, in producing a disturbance of elevation of the water surface at any given station, on any body of water, anywhere in the world. The data required in regard to the station and the body of water are such as are ordinarily shown on good charts, namely, the depths of the water at all points, the location of the shore line, and the location of the station.

[1] Hayford, John F.: *Carnegie Institution of Washington*, Publication No. 317.

(4) Four of the prevailing seiches, or free oscillations under the influence of inertia, on Lake Erie and Lake Michigan-Huron have been isolated. Their periods and probable methods of oscillation have been shown. The relation between these seiches and the uncertainties in daily mean elevations of the water surface at gage stations has been discerned. The appreciation of this relation aids decidedly in obtaining accurate determinations of the daily mean elevation of the mean surface of each lake.

(5) The accuracy with which the elevation of the mean surface of any one of the Great Lakes may be determined for any given day has been decidedly increased. On Lake Erie the elevation of the mean surface of the lake may now be determined as accurately from 1 day of observation at Buffalo as it was formerly possible to fix it from 16 days of observation at that station. Similarly, the elevation of the mean surface of Lake Michigan-Huron may now be determined as accurately from 1 day of observation at Mackinaw as it was formerly possible to determine it from 6 days of observation at that station. When one determines the fluctuation of elevation of the mean surface of a lake he thereby determines the fluctuation in the total water content of the lake.

(6) The relations of the new knowledge indicated in (1) to (5) to four outstanding problems have become evident. The four problems are:

(a) The problem of regulating the elevations of the water surface of each of the Great Lakes—and the rates of flow through the connecting streams, so as to secure the greatest aggregate benefits to navigation, power, development, and sanitation.

(b) The problem of determining the laws of evaporation from large free-water surfaces such as the surface of the Great Lakes.

(c) The problem of correcting the observed elevations of the water surface at a tide gage in such a manner as to remove the disturbances due to winds and fluctuating barometric pressures and thereby to secure a more accurate determination of mean sea level than could otherwise be obtained from said observations.

(d) The problem of determining the direction and rate of the tilting, which is believed to be in progress, of the land underlying and immediately surrounding the Great Lakes.

As to the accuracy of the results, the author considers it possible to determine the mean elevation of the whole of Lake Michigan-Huron, for example on any day, with a probable error of less than ±0.010 foot, and that by using the three stations Milwaukee, Mackinaw, and Harbor Beach it would appear that the change in elevation of the mean surface of the whole lake for any one day may possibly be determined with a probable error of less than ±0.007 foot—an accuracy hitherto unattainable.

NOTES, ABSTRACTS, AND REVIEWS.

Anton D. Udden (1886-1922).

On September 5, 1922, occurred the death of Dr. Anton D. Udden, at San Antonio, Tex. To those who were privileged to be associated with Doctor Udden, even for a short time, the news of his untimely death will be accepted with deepest regret.

It was not until 1917 that Doctor Udden's interest in meteorology was brought to the attention of the Weather Bureau, although he had taught meteorology, among other sciences, at Augustana College, Rock Island, Ill., for a number of years, and had completed most of the work required for the degree of Doctor of Philosophy in the University of Chicago. On January 1, 1918, he entered the service of the Weather Bureau as an observer at Davenport, Iowa; plans for undertaking research work at the Central Office in Washington were annulled by the induction of Doctor Udden into the military service on April 14, 1918, after only three and one-half months at the Davenport station. He was among the first of those selected by the Signal Corps to receive instruction in meteorology at College Station, Tex. Upon completing work in this school, Doctor Udden was assigned to Washington, D. C., and to the meteorological station at Cape May, N. J. Upon the completion of his military service, he resigned from the Weather Bureau to continue his work as instructor in physics at the University of Pennsylvania in Philadelphia. He was appointed McFadden Fellow of the American-Scandinavian Foundation and spent his last two years in study at the University of Copenhagen with Professor Bohr. His strenuous academic activities abroad culminated in a nervous collapse just as he was about to return to the United States. After receiving treatment during the summer in Christiania, he was brought by his wife and father to Texas late in August. His death from heart failure occurred only 11 days after arriving in the United States.

Doctor Udden's quiet demeanor, his modesty, his great capacity for work and study which revealed itself rather by his accomplishments than by brilliant display of knowledge, his genial disposition which remained placid under military circumstances ordinarily capable of irritating one of his attainments, his willingness to undertake commonplace tasks,—all are qualities which impressed his superiors and stimulated his fellows.

The publication of an article prepared by Doctor Udden is contemplated for an early number of the MONTHLY WEATHER REVIEW.—*C. L. M.*

Ştefan C. Hepites (1851-1922).

Notice has been received of the death of the first director of the Central Meteorological Institute of Roumania, Ştefan C. Hepites, at Braila, September 15, 1922, at the age of 71 years. Doctor Hepites was the organizer of the Roumanian Institute and devoted his life to researches in meteorology and other branches of geophysics.

The notice, signed by the present director, E. Otetelişnau, states that, during the reorganization period following the World War, the great experience and competence of the former director was of the utmost value to the Roumanian service.—*C. L. M.*

METEOROLOGICAL STATIONS IN THE ARCTIC.

Supervising Forecaster E. H. Bowie, writing in the Philadelphia *Public Ledger* of November 15, 1922, concerning the establishment of a chain of meteorological stations in the Arctic says:

> Stations are already in operation in Spitzbergen, Iceland, Jan Mayer (east of Greenland), and Alaska, from which regions daily reports are received by radio. The Amundsen Arctic exploration steamship *Maud*[1] is another link in the chain of outposts in the far north.
>
> Steps already have been taken to establish additional radio equipments and weather observatories in Greenland and Baffin Land; later, it seems probable, outposts will be operated in north central Canada and the north shore of Alaska; and eventually the chain of outposts will encircle the North Pole, along the Arctic Circle.

THE SUN'S ACTIVITY, 1890-1920.

[Reprinted from *Nature* (London), September 30, 1922, pp. 465-466.]

The sun, as is well known, is a variable star having a period of approximately 11 years, but, unlike other stars, its variability can be determined from several different visible phenomena and not solely from the total integrated

[1] Cf. this REVIEW, February, 1922, 50: 74.

light emitted. As classed among stars, it is not considered, however, as a regular variable, because the approximate period of 11 years is itself made variable through other minor periods of various lengths.

Though the sun has a dominating action on many terrestrial phenomena, authorities differ as to the exact relation between the pulsations of the two bodies. It is important, therefore, always to keep in mind, so far as possible, the actual state of solar activity at the moment, i. e., whether the sun is in a quiescent state through lack of spots and prominences, or whether it is in a very turbulent condition caused by their abundance.

The data for determining the state of the activity of the sun are published separately year by year in various volumes from different sources, and are only brought

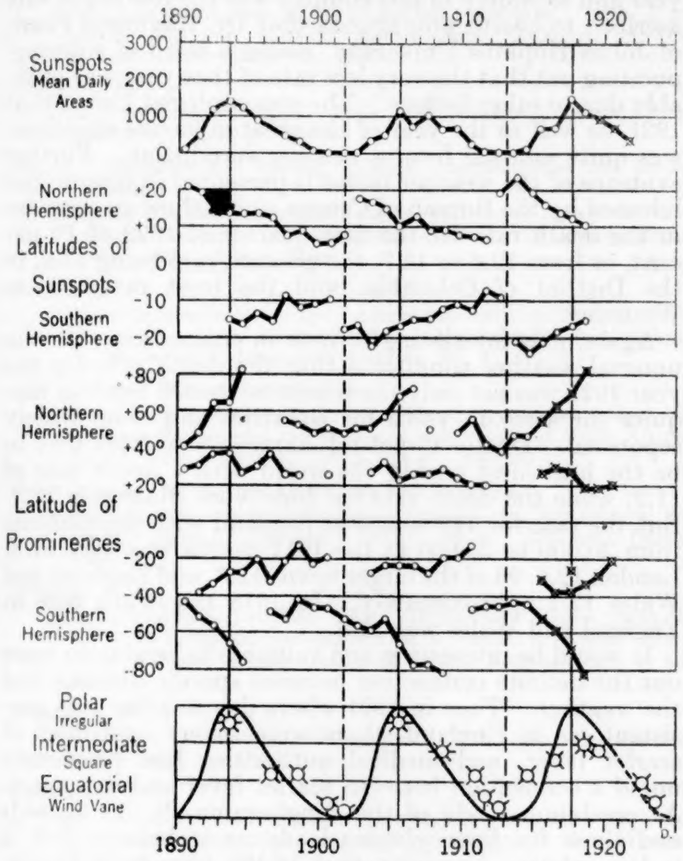


FIGURE 1.

together, probably with some difficulty, by research workers who wish to use them for particular inquiries.

Dr. W. J. S. Lockyer has recently coordinated the solar data regarding the sunspotted area, the latitudes of the activity zones of sunspots and prominences, together with the variations in the form of the corona for the period 1920 *to as near the present as possible*. The accompanying diagram (fig. 1) illustrates the solar changes in graphic form. The following paragraphs deal briefly with each set of curves individually, including the sources of the data:

Mean daily areas of sunspots.—Each of the points in the curve represents the mean of the daily areas of sunspots corrected for foreshortening for each year. The values are published by the Astronomer Royal yearly in the Monthly Notices of the Royal Astronomical Society, the last value published being that for 1918 (vol. 82, p. 485). The three later years marked with crosses are only provisional values.

It will be seen that the maximum spot activity occurred in the years 1893, 1905, and 1917, while the years of minimum were 1901 and 1913. The next minimum will probably fall in 1924 or 1925.

Latitudes of sunspots.—Under this heading there are two sets of curves—one for the northern and the other for the southern hemisphere of the sun. Each point represents the mean heliographic latitude of all spots for each hemisphere throughout the whole year. The data are taken from the same sources as mentioned above. It will be noticed that a new sun-spot cycle is always heralded by outbursts of spots in zones of high latitudes (about 22°), while the zone of spots nearer the equator is dying out.

Latitudes of prominences.—Here also there are two sets of curves, one for each hemisphere; where in the case of the spots there was only one zone for each hemisphere, for prominences there are two zones. Each point in the curves represents the mean latitude of each zone throughout the year. It will be noticed that in each hemisphere the zone in lower latitudes gradually approaches the equator, dying out just before or at sun-spot minimum, while the zone further away from the equator increases its latitude rapidly and dies out at or a little after sunspot maximum. The data up to 1914 are published in the Memoirs of the Kodaikanal Observatory (vol. 1, part ii) by Mr. John Evershed, and the remainder have been extracted from that observatory's bulletins published half yearly, from which the mean yearly latitudes of the zones have been provisionally determined by Doctor Lockyer.

The forms of the corona.—The last curve shows the condition of activity of the sun as indicated by the form which the corona takes when seen at total eclipses.

When the corona (polar form) exhibits streamers all around the solar disc, i. e., in all solar latitudes, this indicates a very turbulent state of the solar atmosphere and a time therefore of maximum activity. At this time the prominences reach their highest latitudes. When the streamers are confined to the equatorial regions and the poles are quite clear and void of streamers, the corona takes an "equatorial" or "wind-vane" form, and the solar activity is at a minimum. Intermediate stages are indicated by the corona taking an "intermediate" or "square" shape. The various forms of the corona are indicated clearly in the curve by three different symbols. The curve also shows the forms expected in the two approaching eclipses, namely, of this and of next year. The form for the present year will be of the "intermediate" type, while that for 1923 should be typical of the "equatorial" type. The data for the various forms of the corona have to be obtained from the individual reports of eclipse expeditions, but those to which reference has here been made have been collected by Doctor Lockyer and published in the Monthly Notices of the Royal Astronomical Society (vol. 82, p. 326).

All the solar phenomena described above thus indicate clearly that the activity of the sun is decidedly on the wane, and that the epoch of minimum disturbance in the solar atmosphere is approaching and will be reached in the year 1924 or 1925.

RAINFALL AT HAIFA, PALESTINE, NOVEMBER, 1921, TO MARCH, 1922.

Mr. Perez W. Etkes, assistant district engineer, has submitted the following data on the rainfall measured at Haifa, Palestine, during the six months November, 1921, to March, 1922, inclusive. The observations were made by Mr. A. Grossman, observer. The values originally submitted were in millimeters and these have been converted into inches.

Table 1.—*Daily rainfall (inches) at Haifa, Palestine.*

Day of month.	1921		1922		
	November.	December.	January.	February.	March.
1		1.31			
2			0.39		
3		0.24	0.12	0.16	0.59
4			0.04	0.04	
5					
6					0.13
7					0.40
8		1.40	0.07		
9		7.20	0.55	0.17	
10		0.35	1.06	0.11	
11		0.42	0.51	0.22	
12		0.30		0.04	
13					
14					
15		0.58			
16		0.95			
17		0.91		0.16	
18		0.27		0.25	
19	0.78	0.09			
20		0.21	0.82	0.18	
21			0.16		
22		0.21			
23			0.32		
24	1.89		0.16		
25	0.67		1.76		
26	0.06		0.07	0.26	
27	0.09	1.26		0.34	
28		0.26	0.58		
29		0.33	0 95		
30			0.25		
31					
Total	3.49	16.29	7.81	2.03	1.12

WEATHER AND DEATH RATE.

After discussing the relation between the birth rate and conditions in Germany as determined by Doctor Roesle, the Berlin correspondent of the *Journal of the American Medical Association* under date of July 29, 1922, says:

It could not be shown that economic conditions exerted a perceptible influence on the death rate. The year 1921 shows the lowest recorded death rate in German cities with more than 15,000 inhabitants, namely, 13.5 per thousand of population, and excluding deaths among strangers and transients the death rate was only 11.9. A comparison of the monthly death rates for former years brings out the fact that during the winter months of January, February, and March, 1921, exceptionally favorable weather conditions must have prevailed. The abnormally mild winter was followed by an abnormally hot summer, but the summer peak of infant mortality did not reach the terrible percentage of the summer of 1911. Also during the autumn of 1921 the weather conditions were favorable. These favorable weather conditions prevailed elsewhere as well, so that favorable death rates for the year 1921 are to be expected also from other countries. Only for the month of December, 1921, was there a higher death rate than for the corresponding month of the previous year, which is explainable by the severe influenza epidemic. The rapid and continued decrease in the death rate *since the war* is due, for the most part, to the improvement in the food situation.

In the United States the decline in the death rate that has been in progress in recent years can not be due to improvement in the food situation but is accredited instead to improvement in medical treatment, higher medical standards, and, in large part, to health crusades and health education. These have to do with "fresh air," sunshine, proper eating, medical inspection, and the like. In the United States the decrease was about 10 per cent, or from 1,496 per 100,000 in 1910 to 1,306 per 100,000 in 1920, according to the census. But 1921 was an unusual year and so widely in this country was the low death rate ascribed to health propaganda that Dr. Raymond Pearl, of Johns Hopkins University, issued a word of warning, pointing out that the very low rate of that year was probably due to other factors. The meteorologist knows that 1921, as well as the year of the great influenza epidemic, was quite unusual from a weather standpoint. Further evidence of the weather factor is presented in figures just released by the Bureau of Census which show an increase in the death rate for the first quarter of 1922 of 10 per cent, or from 12.6 to 13.7, the greatest rate being 17.6, in the District of Columbia, and the least rate 9.6, in Wyoming.

Again, it is interesting to note in connection with the unusual weather conditions that the death rate for the year 1921 was not only the lowest on record but was also quite the same in value for countries and cities widely separated. Doctor Copeland claimed New York City to be the healthiest city in the world with a death rate of 11.2, while the death rate for New York State was 12.2. But the rate for 148 towns in England with populations from 20,000 to 50,000 at the 1911 census was only 11.3, London 12.4, 96 of the larger towns 12.3, and England and Wales 12.1 approximately. In 1918 the death rate in England and Wales was 17.6.

It would be interesting and valuable to be able to trace out the definite connection between specific diseases and the weather. Thus in 1921 where dry weather was persistent, as in England, there were severe epidemics of scarlet fever, and medical authorities had previously noted a connection between scarlet fever and dry years. A correlation study of the Binghamton, N. Y., records and those for Pennsylvania leads me to believe that it is low relative humidity that is the important factor, coupled, of course, with a suitable field for endemic prevalence of the bacterium. There is opportunity for much work along these lines.

It would be interesting, too, and perhaps very valuable, to have statistical data in regard to plant and animal disease and make similar studies.—*John R. Weeks.*

BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Meteorologist in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Argentina. Oficina meteorológica.
Pronóstico del estado del tiempo para la semana que empieza el día . . . Capital federal y región del Rio de la Plata. Enero 5–Febrero 9, 1922. sheets. 50 cm.

Bamford, A. J.
On the general circulation of the air over Ceylon, with special reference to the time of day of rainfall. Colombo. 1922. 7 p. plates. 33½ cm. (Ceylon survey dept. Bulletins of the Colombo observatory. No. 4.)

Chauveau, B.
Électricité atmosphérique. Paris. 1922. fasc. 1. Introduction historique. x, 90 p. 25½ cm.

France. Ministère des travaux publics. Aéronautique and transports aériens.
Codes de transmissions utilisés par les stations et postes météorologiques français. (En vigueur à dater du 15 octobre 1922.) Paris. 1922. 9, x p. 31 cm.

Funke, A.
Mesures de la radiation solaire à Abisko pendant l'été 1914. Nyköping. 1921. 17 p. illus. 30½ cm. (Meddelanden från Statens meteorologisk-hydrografiska anstalt. Bd. 1. No. 3.)

Great Britain. Meteorological office.
Particulars of meteorological reports issued by wireless telegraphy in Great Britain and the countries of Europe and North Africa. Suppl. no. 1. London. 1922. 12 p. 24½ cm.

Great Britain. Ministry of agriculture and fisheries.
Report of the meteorological committee of the Agricultural research council. [London. 1922.] 16 p. 33½ cm. [Manifolded.]

Grunsky, C. E.
Rainfall and run-off studies. With discussion by Messrs. Dana M. Wood, C. F. Marvin [and others]. n. p. 1922. p. 66–136. illus. plate. 23 cm. (Amer. soc. civil engin., Transactions. v. 85. 1922.)

Harvey, R. B., & Wright, R. C.
Frost injury to tomatoes. Washington. 1922. 10 p. fig. 23½ cm. (U. S. Dept. agric., Bulletin. No. 1099.)

Hellmann, G.
Der Nebel in Deutschland. [Berlin.] p. 900–919. 25½ cm. (Sitzungsberichte der preussischen Akademie der Wissenschaften. 52. 1921.)
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General classification of instruments and problems, including bibliography. Washington. 1922. Sec. 1. Aeronautic instruments. 22 p. 29 cm. (Nat. adv. comm. for aeron. Report no. 125.)

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Climatic changes, their nature and causes. New Haven. 1922. xiii, 329 p. illus. 23½ cm.

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Kendrew, W. G.
Climates of the continents. Oxford. 1922. xvi, 387 p. illus. 23 cm.

Mulder, M. E.
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Newnham (Mrs.) E. V.
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Die Beobachtungen der Marinedrachenstationen Breedene/Meer und St. Michel bei Brügge in den Jahren 1915–1918. Hamburg. 1922. 60 p. figs. plates. 30 cm. (Deutsche Seewarte. Aerolog. und hydrogr. Beob. der Deutschen Marine-Stationen. 1914–1918. H. 4.)
Ein Jahr synoptischer Pilot- und Fesselaufstiege. 40 p. illus. 23 cm. (Extr.: Das Wetter. H. 6–8, 10–12. 1912.)

Pettersson, O.
Étude sur les mouvements internes dans la mer et dans l'air. [Göteborg. 1921.] 18 p. illus. plates. 45 cm. (Ur Svenska hydrografisk-biologiska kommissionens skrifter.)
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Schwan, Albrecht.
Über die Abhängigkeit des Vogelesanges von meteorologischen Faktoren, untersucht auf Grund physikalischer Methoden. 71 p. plate. 22 cm. (Extr.: Verhandlungen der Ornithol. Ges. in Bayern. Bd. 15, H. 1–2. 1921/22.

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Cold air drainage. p. 110–115. 26 cm. (Extr.: Plant world. v. 15, no. 5. 1912.)

Spencer, James H.
Our climate. Useful information regarding the climate between the Rocky mountains and the Atlantic coast, with special reference to Maryland and Delaware. Baltimore. n. d. 29 p. illus. 22 cm. (Issued by Md. state weather service and U. S. weather bureau.)

Sweden. Statens meteorologisk-hydrografiska anstalt.
Instruktion för avfattning av inhemska väderlekstelegram gällande fr. o. m. 15 maj 1922. Stockholm. 1922. 32 p. 21½ cm. (No. 202.)
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Thoulet, J.
. . . L'Océanographie. Paris. 1922. ix, 287 p. figs. 19½ cm.

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Discovery of the calculation and the astronomical forecasting of the weather. [Port-au-Prince. 1922.] iii, 7 p. tables. 24½ cm. (Electromagnetic theory of the weather. 12th provisional communication.)

Weber, Gustavus A.
The Weather bureau; its history, activities and organization. New York. 1922. xii, 87 p. 22½ cm. (Institute for government research. Service monographs of the United States government, no. 9.)

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Notes on the efficiency of various systems of air-conditioning in a munition factory. Washington. 1922. 17 p. illus. 23 cm. (U. S. Public health service. Repr.: Public health reports, no. 729.)

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. F. TALMAN, Meteorologist in Charge of Library.

The following titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

Aéro-revue. Bern. 1. Jahrg. Oct., 1922.
Gsell, Robert. Nebel und Dunst. p. 146–147.

Astronomie. Paris. 36. année. Oct. 1922.
Boutaric, A. Le rayonnement nocturne. p. 447–455.
F[lammarion], C[amille]. Le pays le plus chaud du mond. p. 459–460.

Aviation. New York. v. 13. 1922.
U. S. National advisory committee for aeronautics. Stresses produced on airships by gusty air. p. 603. (Oct. 30.)
Beacons and wind indicators for night flying. p. 688–689. (Nov. 20.)

Brazil. Directoria de meteorologia. Revista mensal de meteorologia. Rio de Janeiro. v. 1. Junho, julho & agosto, 1922.
Berlink, E. L. Notas sobre a geada no estado de S. Paulo. p. 33–36.
Xavier, Raul. A primeria experiencia de Estacão-agraria de S. Simão (S. Paulo)—Milho "Champagne." p. 25–30.

Engineering news-record. New York. v. 89. 1922.
Hill, C. S. Lost time in construction. 3. Rain and mud delays. p. 645–647.
Appraisal of flood protection benefits and damages in the Miami Valley. p. 831–835.

France. Académie des sciences. Comptes rendus. Paris. t. 175. 23 Oct., 1922.
Constantin, Joessel, & Daloz. Sur un bateau qui remont le vent en se servant du vent lui-même comme puissance motrice. p. 683–685.

Geographical journal. London. v. 60. Oct., 1922.
Ray, Satyendra. A note on Reeves's experiment. p. 286–288. [On a north and south directive force in the atmosphere.]
Reeves, E. A. The evidence of a true north and south directive force in the atmosphere. p. 268–288.

Great Britain. Meteorological office. Monthly meteorological charts. North Atlantic ocean. Nov., 1922.
Smith, L. A. Brooke-. The barometer, weather and wireless telegraphy.

Heating and ventilating magazine. New York. v. 19. Oct. 1922.
O'Conor, G. J. Heating and ventilating the earth. A conception of the vast air movements and heat exchanges throughout the world which mark the hand of the master engineer. p. 38–40.

Meteorological magazine. London. v. 57. Oct., 1922.
Bamford, A. J. The design of rain-gauges. p. 240–244.
Geostrophic dividers. p. 252–253.
Gold, E. Exposure of rain-gauges. p. 231–235.
Harries, H. A red rainbow. p. 246–247.
Some observations of waterspouts and allied phenomena. p. 248–250.

Meteorologische Zeitschrift. Braunschweig. Bd. 39. 1922.
Groismayer, Fritz. Neue Ausdrücke für die Bewölkung. p. 280–281. (Sept.)
Köhler, Hilding. Eine quantische Verteilung von Materie in der Atmosphäre. p. 263–267. (Sept.)
Langbeck, K. Die regionalen Besonderheiten der Gewitterentstehung in Norddeutschland. p. 257–263. (Sept.)
Linke, Franz. Das Prött-Theorem. p. 267–272. (Sept.)
Maurer, H. Die meteorologischen Zeitabschnitte. p. 277–278. (Sept.)
Rubenstein, E. Über eine Methode der Bestimmung von Perioden. p. 272–276. (Sept.)
Schmauss, A. Kohärente und inkohärente Drucksysteme. p. 278–280. (Sept.)
Schoenrock, A. Nachruf auf E. Stelling. p. 276–277. (Sept.) [Obituary.]
Visser, S. W. Ein Zirkumhorizontalbogen nach Bravais in Weltevreden beobachtet. p. 283–286. (Sept.)
Voüte, J. Beobachtungen des "grünen Strahles." p. 281–283. (Sept.)

Meteorologische Zeitschrift—Continued.
Baur, Franz. Die 11-jährige Temperaturperiode im Europa in ihrem Verhältnis zur Sonnenfleckenperiods. p. 289–293. (Okt.)
Dorno, C. Fortschritte in Strahlungsmessungen. p. 303–323. (Okt.)
Gentzen, G. Starke Luftdruckschwankungen bei einem Gewitter. p. 334–335. (Okt.)
Kähler, K. Über die Ursachen einiger einfachen luftelektrischen Störungen. p. 293–298. (Okt.)
Langbeck, K. Der Tagesgang in der Entstehung der Gewitterzüge und eine hypothetische Erklärung für deren periodische Aufeinanderfolge. p. 298–303. (Okt.)
Maey, E. Beobachtungen von Nebelbogen. p. 324–325. (Okt.)
Meyer, R. Bemerkenswerte Regenbogenerscheinungen. p. 325–326. (Okt.)
Wolfer, A. Tafeln der Sonnenfleckenhäufigkeit für die Jahre 1902 bis 1920. p. 326–328. (Okt.)

Nature. London. v. 110. 1922.
Cornish, Vaughan. The isothermal frontier of ancient cities. p. 558–559. (Oct. 21.) [Abstract.]
Cave, C. J. P. The green ray at sunset and sunrise. p. 604–605. (Nov. 4.)
McLean, R. C. A broadcast "rainbow." p. 605. (Nov. 4.)
Simpson, G. C. One possible cause for atmospheric electric phenomena; a reply. p. 604. (Nov. 4.)
Solar radiation and its changes. p. 608–609. (Nov. 4.) [Review of Annals Astrophysical observatory, v. 4.]
Cole, Grenville A. J. Volcanic shower in the N. Atlantic. p. 635. (Nov 11.)

Nature. Paris. 50 année. 11 Nov., 1922.
La gelée et les statues en pierre placées dans les jardins. Suppl. p. 149–150. [Methods of protecting statuary, etc., from effects of frost.]
Montessus de Ballore, [Fernand] de. L'état actual de la sismologie. p. 307–312.

Royal Dublin society. Scientific proceedings. Dublin. v. 17. August, 1922.
Nolan, J. J., & Enright, J. Experiments on the electrification produced by breaking up water, with special application to Simpson's theory of the electricity of thunderstorms. p. 1–11.

Science. New York. v. 56. 1922.
Glock, Waldo S. Deficiency of atmospheric dust in coal. p. 484–485. (Oct. 27.)
Macelwane, James B. Some seismological evidence that is not evident. p. 478–480. (Oct. 27.)
Meisinger, C. LeRoy. A new aerological summary. p. 482–484. (Oct. 27.)
Manson, Marsden. The evolution of climates: a rejoinder. p. 571–573. (Nov. 17.)

Tycos-Rochester. Rochester, N. Y. v. 12. October, 1922.
Gregg, W. R. Upper air explorations of the Weather bureau. p. 19–21.
Storm, Marian. June was the month for rain insurance. p. 39. [Rep. from New York evening post.]

Wetter. Berlin. 39. Jahrg. 1922.
Lindemann, C. Höchste und tiefste Temperaturen in Dresden, Leipzig, Bautzen, Zittau, Chemnitz, Freiberg, Elster, and Reitzenhain in den Monaten und Jahren 1866/1915. p. 118–121. (Juli/Aug., 1922.) p. 146–148. (Sept./Okt., 1922.)
Appelrath, Carl. "Wettererscheinungen und Naturereignisse in Aachens historischer Zeit." p. 148–151. (Sept./Okt.)
Fischer, Rudolf. Ein "zweiter Sommer" in der ersten Hälfte des Oktober 1921. p. 153–154. (Sept./Okt.)
Goetze, K. Die Bauernregel vom Siebenschlafer. p. 143–146. (Sept./Okt.)
Hennig, R. Die äussersten Grenztermine der jahreszeitlich beschränkten Witterungselemente in Deutschland (ohne Bergstationen). p. 143–146. (Sept./Okt.)
Knoch, K. Ein Gewitterwarnungsdienst im 16. Jahrhundert. p. 152–153. (Sept./Okt.)
Malsch, W. Leuchtende Bänder am Nachthimmel. p. 134–136. (Sept./Okt.)
Meyer, R. Beobachtungen über das Verhalten der Schneedecke. p. 138–141. (Sept./Okt.)
Meyer, R. Der tägliche Gang der Niederschläge in Riga. p. 141–143. (Sept./Okt.)
Schmauss, A. Die Verbreitung der Wettervorhersage. p. 155–156. (Sept./Okt.)
Schmauss, A. Die Wirkung der Lichtes auf den Organismus. p. 151–152. (Sept./Okt.)
Troeger, Heinz. Kurslinie und Mammatusform. p. 156–157. (Sept./Okt.)

SOLAR OBSERVATIONS.

SOLAR AND SKY RADIATION MEASUREMENTS DURING OCTOBER, 1922.

By HERBERT H. KIMBALL, In Charge, Solar Radiation Investigations.

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to this REVIEW for April, 1920, 48: 225.

From Table 1 it is seen that direct solar radiation intensities averaged slightly above the normal for October at Washington and Madison and slightly below the normal at Lincoln. A noon reading of 1.444 gram-calories per minute per square centimeter of normal surface, measured at Washington on the 31st, equals the highest October reading previously obtained at that station.

Table 2 shows that the total solar and sky radiation received on a horizontal surface averaged above the October normal at Madison and close to normal at Washington.

Skylight-polarization measurements made on 12 days at Washington give a mean of 59 per cent, with a maximum of 74 per cent on the 31st. At Madison, measurements made on five days give a mean of 70 per cent, with a maximum of 74 per cent on the 18th. These are above the average polarization values for October at the respective stations, and the maximum at Washington is the highest polarization measurement ever obtained at that station.

TABLE 1.—*Solar radiation intensities during October, 1922.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance. 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon.
	75th meridian time.	Air mass. A. M.					P. M.				Local mean solar time.
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Oct. 2	10.21		0.82	0.95							10.59
3	9.83			0.58	0.83						10.21
5	12.68				0.72						14.60
11	9.47				1.22						18.59
12	7.87			0.80	1.11						7.87
13	4.95	0.92	1.04	1.16	1.31		1.30	1.06	0.91		4.17
18	4.57		0.77	1.02	1.22	1.46	1.19	0.93	0.87	0.76	3.30
19	4.37	0.87	0.96	1.03	1.14		1.27	1.09	0.96	0.87	4.17
20	5.56	0.46	0.54	0.62	0.85		1.17	0.98	0.82	0.68	4.95
21	4.37		0.63	0.77	0.95	1.17					4.57
26	4.75	0.68									4.37
27	4.75		0.82	0.98	1.17	1.40		1.03	0.60	0.53	4.75
30	4.37		0.54	0.68	1.10		1.26	1.11	0.97	0.85	3.30
31	4.17	1.01	1.10	1.22	1.37	1.53	1.34	1.19	1.05	0.94	3.57
Means		**0.79**	**0.80**	**0.89**	**1.08**	**1.39**	**1.26**	**1.06**	**0.88**	**0.77**	
Departures		**+0.04**	**−0.02**	**−0.02**	**−0.02**		**+0.16**	**+0.16**	**+0.11**	**+0.09**	

TABLE 1.—*Solar radiation intensities during October, 1922*—Continued.

Madison, Wis.

Date.	Sun's zenith distance. 8a. m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon.
	75th meridian ime.	Air mass. A. M.					P. M.				Local mean solar time.
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm.	c	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Oct. 9	6.76				1.22						5.79
10	6.50				1.27	1.42	1.27	1.12	1.00		6.50
11	6.27		0.87	0.99							4.75
12	3.63		1.06	1.19	1.34	1.52		1.19			3.63
18	3.15			1.25	1.37						2.06
19	3.99		0.86	0.77	1.25			0.99			5.16
25	5.79						1.33				5.36
27	5.16			0.88							6.76
Means			**0.93**	**1.06**	**1.29**	**(1.47)**	**(1.30)**	**1.10**	**(1.00)**		
Departures			**+0.01**	**+0.01**	**+0.11**		**+0.12**	**+0.08**	**+0.10**		

Lincoln, Neb.

Date.	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
Oct. 4	9.83		0.68	0.82	0.99						8.48
9	4.37				1.26		1.26	0.85	0.72	0.55	4.17
10	3.81			1.01	1.25		1.23	1.02	0.93	0.82	6.02
11	5.16		0.89	1.05	1.24	1.46	1.31	1.14	1.00	0.88	3.15
12	3.45				1.39		1.17	0.98	0.80		2.74
14	4.37						1.17	0.91	0.78	0.58	3.45
18	2.87						1.39	1.13	0.99	0.90	2.74
19	4.17	0.84	0.96	1.10	1.28	1.48	1.27	1.05	0.90	0.79	4.95
20	5.16		0.92	1.07	1.23	1.45					6.50
23	3.81			1.07	1.32						4.37
24	4.57			1.18		1.55	1.30	1.07	0.93	0.80	4.17
25	4.95			0.86							5.28
26	5.36			1.13	1.29		1.18	1.01	0.89	0.80	6.02
Means		**(0.84)**	**0.86**	**1.03**	**1.25**	**1.48**	**1.25**	**1.02**	**0.88**	**0.76**	
Departures		**−0.06**	**−0.10**	**−0.07**	**−0.03**		**±0.00**	**−0.05**	**−0.05**	**−0.06**	

* Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface.*

Week beginning.	Average daily radiation. Washington.	Madison.	Lincoln.	Average daily departure for the week. Washington.	Madison.	Lincoln.	Excess or deficiency since first of year. Washington.	Madison.	Lincoln.
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Oct. 1	308	256		−20	−29		−3,626	−1,853	
8	277	275		−30	+19		−3,833	−1,717	
15	330	303		+42	+76		−3,540	−1,187	
22	282	248		+12	+42		−3,453	− 890	
29	236	151		−16	−36		−3,563	−1,143	

MEASUREMENTS OF THE SOLAR CONSTANT OF RADIATION AT CALAMA, CHILE.

NOTE.—The reports from Calama having been delayed in transmission from South America will appear in the next issue of the REVIEW.—*Editor.*

WEATHER OF NORTH AMERICA AND ADJACENT OCEANS.

NORTH ATLANTIC OCEAN.

By F. A. YOUNG.

The average pressure for the month of October was considerably below the normal at land stations in Newfoundland and eastern Canada, as well as in a portion of the West Indies, while the negative departure at the Azores was unusually large. The pressure was not far from the normal at Hatteras, Bermuda, and Porto Rico, while it was considerably above on the north coast of Scotland. This reversal of the usual atmospheric conditions, with the Azores HIGH often replaced by a LOW and abnormally high pressure occurring in the region normally occupied by the Icelandic LOW, was responsible for a good deal of anomalous weather over the territory between these two centers of action.

Fog was unusually prevalent over the Grand Banks during the month, as it was observed on 14 days from a number of vessels in that region, which is considerably above the normal as shown on the Pilot Chart. Fog was also observed on from 9 to 10 days off the coast of Nova Scotia and New England, while it was comparatively rare in European waters.

The number of days with winds of gale force was very much larger than usual over the major portion of the ocean, and a number of storms of an extra tropical nature extended as far south as the 35th parallel, while tropical disturbances of varying intensities were unusually frequent, especially for so late in the season.

On the 3d and 4th there was an area of low pressure of moderate intensity central near St. Johns, Newfoundland, that between the 4th and 5th moved rapidly eastward, increasing in extent and violence, and on the latter date the center was near latitude 52° N., longitude 37° W., with winds of hurricane force in the southern and southwestern quadrants. Storm logs follow:

American S. S. *Nobles:*

Gale began on the 3d, wind NNW. Lowest barometer 29.11 inches at 2 a.m. on the 5th, wind S., 6, in latitude 48° N., longitude 41° 40′ W. End on the 6th. Highest force of wind 12; shifts S.-NNW.

British S. S. *Galtymore:*

Gale began on the 3d, wind W. Lowest barometer 28.59 inches at 4 p.m. on the 5th, wind SE., 3, in latitude 51° 45′ N., longitude 39° 44′ W. End on the 6th, wind W. Highest force of wind 11; shifts NW.-SW.-W.

On the 3d and 4th there was also a disturbance over the eastern section of the steamer lanes, the storm area on the former date extending as far south as the 40th parallel. Storm logs:

British S. S. *Kenbane Head:*

Gale began on the 3d, wind NNW., 7. Lowest barometer 28.82 inches at 2:30 p.m. on the 3d, wind NW., in latitude 55° 31′ N., longitude 37° 15′ W. End on the 3d, wind NW. Highest force of wind 8, NW.; shifts NNW.-NW.

British S. S. *Ocean Prince:*

Gale began on the 4th, wind SW. Lowest barometer 29.77 inches at 1 p.m. on the 4th, wind SW., 10, in latitude 39° 40′ N., longitude 40° W. End on the 5th, wind NW. Highest force of wind 10, S.; shifts SSW.-S.

Dutch S. S. *Westerdijk:*

Gale began on the 4th, wind SSE. Lowest barometer 28.87 inches at 5 p.m. on the 4th, wind N., 12, in latitude 46° 11′ N., longitude 44° 03′ W. End on the 5th, wind W. Highest force of wind 12, N.; shifts SSE.-N.-W.

From the 9th to the 13th heavy weather was prevalent over the middle and eastern sections of the steamer lanes, as shown by following storm logs:

American S. S. *Hoxie:*

Gale began on the 9th, wind SW. Lowest barometer 29.78 inches at 3 p. m. on the 9th, wind SW., 8, in latitude 50° 38′ N., longitude 34° 40′ W. End on the 10th, wind NW. Highest force of wind 9; shifts SW.-NW.

Danish S. S. *Frederick VIII:*

Gale began on the 10th, wind SE. Lowest barometer 29.89 inches at 8 a. m. on the 10th, wind SW., 10, in latitude 54° 29′ N., longitude 28° 20′ W. End on the 11th, wind NNW. Highest force of wind 10; shifts not given.

American S. S. *Sundance:*

Gale began on the 12th, wind NNW. Lowest barometer 29.01 inches at midnight on the 12th, wind NNW., 10, in latitude 48° 30′ N., longitude 22° 15′ W. End at 6 a. m. on the 13th, wind NNW. Highest force of wind 10; steady from NNW.

Norwegian S. S. *Balto:*

Gale began on the 12th, wind NNE. Lowest barometer 29.34 inches at 6 a. m. on the 13th, wind NNE., 10, in latitude 51° 24′ N., longitude 24° 10′ W. End on the 13th, wind NNE. Highest force of wind 10; steady from NNE.

American S. S. *Mongolia:*

Gale began on the 12th, wind SE. Lowest barometer 29.24 inches at 10:30 a. m. on the 12th, wind SE., 8, in latitude 49° 30′ N., longitude 19° 18′ W. End on the 13th, wind SSE. Highest force of wind 10; shifts NE.-SE.

From the 9th to the morning of the 13th there was also an area of low pressure in the vicinity of Swan Island that on the evening of the latter date began to move northward, increasing in intensity, and on the 16th was central near Apalachicola, Fla. Storm log:

American S. S. *City of Weatherford:*

Gale began at 8 a. m. on the 14th, wind NNE. Lowest barometer 29.83 inches at 6 p. m. on the 14th, wind NNE., 8, in latitude 27° 25′ N., longitude 86° 54′ W. End at 6 p. m. on the 14th, wind NNE., 6. Highest force of wind 8, NNE.; steady from NNE.

The American S. S. *Chalmette* on her voyage from Habana to New Orleans, at 8 a. m. on the 15th, in latitude 26° N., longitude 85° W., experienced a westerly wind, force 8, and a barometer reading of 29.70 inches.

On the 14th a disturbance of considerable intensity was central near latitude 50° N., longitude 40° W.; this moved rapidly eastward, and on the 16th was near latitude 45° N., longitude 18° W. It then curved sharply toward the south, and on the 17th was off the coast of Spain. Storm logs:

American S. S. *West Celina:*

Gale began on the 14th, wind S. Lowest barometer 29.30 inches at 5 a. m. on the 14th, wind W., 7, in latitude 50° 41′ N., longitude 41° 23′ W. End on the 15th, wind NW., 5. Highest force of wind 11; shifts NW.-W.-NW.

Belgian S. S. *Mercier:*

Gale began on the 14th, wind WNW. Lowest barometer 29.72 inches at 8 a. m. on the 14th, wind WNW., in latitude 47° 40′ N., longitude 38° 46′ W. End on the 15th, wind WNW. Highest force of wind 11, WNW.; steady from WNW.

British S. S. *Henry Deutsch de la Meurthe:*

Gale began on the 15th, wind W. Lowest barometer 29.31 inches at 11:30 p. m. on the 15th, wind NW., 9, in latitude 43° 50′ N., longitude 18° 30′ W. End on the 17th, wind NNW. Highest force of wind 10; shifts SSW.-W.-NW.-NNW.

Italian S. S. *Citta di Messina:*

Gale began on the 17th, wind SSW., 8. Lowest barometer 29.28 inches at 2 p. m. on the 17th, wind SSW., 8, in latitude 38° 15′ N., longitude 12° 20′ W. End on the 18th, wind SW. Highest force of wind 10, SW.; shifts WSW.-SSW.

On the 15th the second tropical disturbance of the month appeared, central east of Swan Island, as described elsewhere. Charts VIII to XII show the conditions from the 16th to 20th, inclusive. A number of vessels encountered winds of hurricane force during this period, as shown by the following storm logs:

British S. S. *San Bruno:*

Gale began on the 16th, wind WNW., 7. Lowest barometer 29.57 inches at 3:30 p. m. on the 16th, wind NW., 8, in latitude 18° 03′ N., longitude 83° 22′ W. End on the 17th, wind NNW., 7. Highest force of wind 11; shifts WNW.-NW.-NNW.

The Honduras S. S. *Ceiba* reports that on the morning of the 17th moderate westerly winds prevailed, barometer 29.55 inches. The wind backed toward the south, and at 7 a. m. on the 18th, in latitude 20° 10′ N., longitude 87° 10′ W., it was blowing from that quarter with a force of 10, while the barometer had dropped to 29.08 inches. For several hours it continued to blow from the south, with a gradually rising barometer. By 7 p. m. the wind had moderated to SSE., 5, and the barometer read 29.50 inches.

American S. S. *Shenandoah:*

Gale began on the 17th, wind NE. Lowest barometer 29.40 inches at 7:30 p. m. on the 17th, wind WNW., 12, in latitude 20° 05′ N., longitude 86° 05′ W. End on the 18th, wind SW. Highest force of wind 12; shifts NE.-N.-NW.-WNW.-W.-SW.

The Honduran S. S. *Hibueras* at 10 a. m. on the 18th, in latitude 22° 40′ N., longitude 88° 28′ W., reported wind NE., 7, barometer 29.74 inches. The wind changed but little in force, backing gradually with slowly falling barometer until noon of the 19th, the observations at that time being, wind NW., 8, barometer 29.63 inches. Sometime between 6 p. m. of the 19th and 6 a. m. of the 20th the wind veered to NE., reaching its maximum force of 12 at the latter hour, when also occurred the lowest barometer reading of 29.42; position, latitude 20° 10′ N., longitude 92° 06′ W.

On the 20th and 21st there was an area of low pressure near the Bahamas and northeasterly winds of gale force prevailed over the region between the 29th and 35th parallels. Storm logs:

American S. S. *San Bruno:*

Gale began on the 19th, wind NE., 7. Lowest barometer 29.94 inches at 9 a. m. on the 19th, wind NE., 8, in latitude 30° 06′ N., longitude 79° 20′ W. End on the 20th, wind NE., 7; shifts NE.-ENE.-NE. by E.

American S. S. *Texan:*

Gale began on the 21st, wind NE. Lowest barometer 29.96 inches at 8 a. m. on the 21st, wind NE., 7, in latitude 29° 40′ N., longitude 74° 15′ W. End on the 21st, wind NE., 5. Highest force of wind 8, NE.; steady from NE.

From the 18th to the 22d moderate to strong gales were the rule over the eastern section of the ocean, and on the 19th there was also a fairly well developed disturbance in the vicinity of Newfoundland. Storm logs:

British S. S. *Cadillac:*

Gale began on the 17th, wind E. Lowest barometer 29.68 inches at 5:45 a. m. on the 18th, wind E., 8, in latitude 48° 19′ N., longitude 11° 12′ W. End on the 20th, wind NE. Highest force of wind 8, E.; steady from E.

Dutch S. S. *Burgerdijk:*

Gale began on the 18th, wind E. Lowest barometer 29.64 inches at 8 p. m. on the 18th, wind E., 8, in latitude 49° 37′ N., longitude 18° 53′ W. End on the 22d, wind ENE. Highest force of wind 9; steady ENE.

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Danish S. S. *Tongking:*

Gale began on the 19th, wind ENE. Lowest barometer 29.65 inches at 2 a. m. on the 21st, wind ENE., in latitude 46° 50′ N., longitude 21° 30′ W. End on the 22d, wind E. Highest force of wind 8; steady from ENE.

British S. S. *Stanmore:*

Gale began on the 19th, wind SW. Lowest barometer 29.37 inches at 11:30 a. m. on the 19th, wind SW., 8, in latitude 46° 28′ N., longitude 53° 04′ W. End on the 19th, wind SW. Highest force of wind 8, SW.; wind unsteady but no shifts.

On the 21st there was a disturbance near latitude 44° N., longitude 45° W., that moved rapidly eastward during the next 24 hours, as by the 22d the center had reached the 35th meridian. Storm log:

British S. S. *Stanmore:*

Gale began on the 21st, wind SE. Lowest barometer 29.27 inches at 6 a. m. on the 22d, wind SW., 8, in latitude 51° 30′ N., longitude 39° 49′ W. End on the 22d, wind SW. Highest force of wind 10, SE.; shifts SE.-SW.

On the 21st and 22d westerly to northwesterly winds of gale force were encountered off the Spanish coast. Storm log:

Italian S. S. *Argentina:*

Gale began on the 20th, wind S. Lowest barometer 29.15 inches at 6 p. m. on the 21st, wind WNW., in latitude 38° N., longitude 16° W. End on the 23d, wind NW. Highest force of wind 8; shifts not given.

On the 24th and 25th the coast of Nova Scotia was covered by an area of low pressure of limited extent, and on the 26th strong gales were reported over the eastern section of the steamer lanes. Storm logs:

American S. S. *Wildwood:*

Gale began on the 24th, wind S. Lowest barometer 29.88 inches at 4 p. m. on the 24th, in latitude 41° 15′ N., longitude 56° W. End on the 25th, wind NE. Highest force of wind 10; shifts S.-NW.

Belgian S. S. *Sunoco:*

Gale began on the 26th, wind S. Lowest barometer 29.77 inches at 3 a. m. on the 26th, wind S., 10, in latitude 49° 16′ N., longitude 12° 51′ W. End on the 27th, wind WNW. Highest force of wind 10; shifts S.-W.

From the 29th until the end of the month a number of vessels encountered gales of varying intensities in different sections of the ocean north of the 40th parallel. Storm logs:

American S. S. *Wildwood:*

Gale began on the 29th, wind SE. Lowest barometer 30.03 inches at 4 p. m. on the 29th, in latitude 49° N., longitude 31° W. End on the 30th. Highest force of wind 8; shifts S.-ESE.

Dutch S. S. *Prins der Nederlanden:*

Gale began on the 29th, wind NE. Lowest barometer 29.35 inches at 8 a. m. on the 29th, wind NE., in latitude 49° 35′ N., longitude 4° 42′ W. End on the 30th, wind NE. Highest force of wind 10; steady from NE.

From the 26th to the 31st there was an area of low pressure in the Gulf of Mexico that was of moderate intensity and not accompanied by unusual weather or heavy winds.

NORTH PACIFIC OCEAN.

By WILLIS E. HURD.

The weather over the North Pacific Ocean during October, 1922, exhibited the usual seasonal increase in energy over that of September, though the few reports and other information received from the Far East up to this writing indicated a less number of typhoons. The middle latitude disturbances both east and west, however, showed an increase in energy, and at least one tropical cyclone made itself felt off the west coast of Mexico during the last days of the rainy season.

It is noted in the September report of the Rev. José Coronas, S. J., of the Manila Observatory, that a typhoon which originated on the 25th well to the eastward of the Philippine Islands had entered the China coast on the 29th. Later information indicates that this storm skirted the coast on the 29th and 30th, and that it then moved northeastward over the western part of the Eastern Sea on October 1, entered the Japan Sea on the 2d, and was last heard from over the Okhotsk Sea on the 3d.

The one well-developed typhoon of October of which the Weather Bureau has accurate information (in the absence of the special report from Father Coronas for this month) is that of the 3d to 9th. This storm was apparent as a mere depression over the Marianas on the 3d. It intensified in energy on the 4th and moved westward, but soon recurved and on the 6th and part of the 7th was moving northward along or near the 136th meridian, between the 20th and 28th parallels. During the 7th it swerved toward the northeast, its center touching the southeast coast of Japan on the 8th, and was last seen on the 9th to the eastward of the Kuriles.

Among the Bureau's weather-reporting vessels, the American S. S. *President Lincoln*, Capt. R. Drennan, Observer W Calcutt, second officer, Honolulu toward Yokohama, was perhaps most heavily involved in this typhoon. From 5 a. m. to 1 p. m. of the 8th the ship was between latitudes 35° and 35 05′ N., longitudes 141° 10′ and 141° 20′ W. The following table, pressure corrected, shows the weather experienced for several hours on that date:

Time.	Wind.	Pressure.	Remarks.
		Inches.	
5 a. m.	ENE. 6	29.09	Light rain, heavy easterly swell.
6 a. m.	ENE. 8-9	28.85	
7 a. m.	NE. 11-12		Barometer oscillating between 28.79 and 28.89 inches.
8 a. m.	NE. 12	28.69-28.89	Heavy rain, high seas.
9 a. m.	NE. 12	28.67-28.79	
10 a. m.	NNE. 12	28.73-28.85	
11 a. m.	N. 11	28.99-29.07	
12 noon	NW. 10-11	29.18	High, confused seas.
1 p. m.	NW. 10	29.33	Very high swells; confused sea.
2 p. m.	NWxW. 8	29.41	
3 p. m.	W. 7	29.44	
4 p. m.	SW. 5-6	29.46	In lee of land, but swell heavy.

The British S. S. *Shabonee*, Capt. I. D. Llewellyn, bound from Japan toward San Francisco, also encountered the typhoon on the 8th in 38° 20′ N., 148° E. At noon the master received a warning from Japan that a typhoon was to the southwestward. The ship's barometer was then 29.53 inches, corrected; wind south, force 6. At 6 p. m. the pressure was 29.27; wind 8 from south; very threatening in the WSW.; sea high and confused. To quote:

9 p. m. Barometer 29.05 inches, still falling rapidly. Decided ship was in the direct path of the storm. Headed her to the southeast, then south, keeping her on starboard tack so as to edge her into the right-hand semicircle and be able to take advantage of the west wind. Wind south 10. Fierce squalls.

10 p. m. Barometer 28.92 inches. Mountainous cross seas; terrific squalls. Glass still falling. Wind SSW., force 10-11, commencing to haul.

11 p. m. Barometer 28.80 inches. Wind hauling to westward; terrific squalls. High cross sea anywhere from SE. to west.

Midnight. Barometer 28.80 inches, steady. Wind west, 10 to 11. Mountainous seas. Decided storm center had crossed our stern and gone away to the nor'ard. Ship in good trim. Decided to take advantage of fair wind and run. Put the ship head east.

On October 28 a tropical depression which appeared over the Marianas moved northward to or near the Bonin Islands on the 31st. No information is at hand as to its intensity.

An important tropical cyclone developed in the Mexican region this month. Nothing has reached the Weather Bureau concerning it except through the medium of the press and a weather report from the American S. S. *Mystic*. According to the Los Angeles Evening World, of October 20, 1922, the British S. S. *Bermuda*, Norfolk to the Orient, via Portland, Oreg., was involved in this hurricane on October 15, while passing Cape San Lucas. The ship was considerably damaged by the encounter and was forced to limp up the coast into port for repairs. The *Mystic*, Capt. J. W. Kirchner, New Orleans toward San Francisco, was in latitude 20° 56′ N., longitude 108° 57′ W., at 2 p. m., after an hour becalmed in the storm center, when the wind suddenly came on in a northwest hurricane, with corrected pressure reading of 28.46 inches. The captain is reported to have said:

This is one of the biggest barometer drops I have seen since I have been at sea. * * * The wind blew 120 miles an hour. I have never seen anything like it. * * * The hurricane lasted for 12 hours and was purely a local affair, as far as I could ascertain by wireless. We were hove to for 12 hours with full steam ahead, and then could not keep her head to wind.

From the 9th to the 11th, between 11° and 15° N. and 88° and 98° W., north-northeasterly to west-northwesterly gales, force 7-8, were reported by two steamships, but direct evidences of cyclonic activity in connection therewith are wanting.

In the issue of the New York Maritime Register for November 8, 1922, appears the following item, the exact reference to which is obscure:

SAN SALVADOR, Oct. 31.—Several vessels have foundered in a gale along the Pacific coast.

Several continental storms entered the ocean from Asia during the month. After passing northeastward these either died out or combined with the Aleutian LOW and struggled eastward as the LOW fluctuated from Bering Sea into the Gulf of Alaska. On the 16th-17th a storm from China entered the Eastern Sea and was central on the 18th east of Japan, whence it moved northeastward into the ocean. It was closely followed by another storm from the Japan Sea. These cyclones gave moderate gales in their respective areas over the western part of the ocean during the 17th, 18th, and 19th.

The Aleutian LOW became locally strong over the western Aleutians on the 3d. It moved eastward over the Gulf of Alaska on the 4th and 5th, then re-developed over the western area on the 6th. From this time until the 9th it exhibited a storm area of considerable proportions which caused strong gales over the northern routes for some distance east and west of the 180th meridian. On the 6th, near latitude 53° 40′ N., longitude 164° W., the U. S. S. *Bear*, Commander C. S. Cochran, Observer Henry Coyle, cruising in Alaskan waters, was in this storm area. At 10 a. m. the barometer read 29.04 inches (corrected), wind shifting from SSE. to SW., force 9. To quote:

At noon, October 7, SW. 9, 29.09 inches. Barometer at 29.06 inches for practically 24 hours, wind SW. 9-10. From 10 a. m., when we entered the area of lowest barometer, it cleared from overcast and rain, and from then on until the finish of the gale it was never overcast, but waves of blue sky and passing rain squalls, accompanied by heavy wind, alternately passed over. The storm blew out about 4 p. m. of the 8th.

The highest wind force reported during this period was 11 from a westerly direction, observed by the American S. S. *West Kader* near 50° 13′ N., 171° 48′ W., on the 3d. This steamship, eastward bound from Japan, experienced rough weather from September 30 to October 7, between longitudes 165° E. and 147° W., on the northern route.

The center of activity of the Aleutian LOW was over the Gulf of Alaska from the 16th to the 25th, displaying con-

siderable energy, especially during the last half of the period, and several vessels reported moderate to strong gales. After a lull, the LOW again intensified on the 28th and 29th.

The North Pacific HIGH continued with remarkable steadfastness throughout the month, and seems to have been unbroken except for a depression, of little consequence so far as known, between Hawaii and San Francisco on the 14th and 15th.

Pressure at Dutch Harbor was below normal for the month, showing a marked change from September. The average pressure, based on p. m. observations, was 29.47 inches, as compared with a normal of 29.70 inches. The change from the preceding month was −0.49 inch. The highest pressure, 30.12 inches, occurred on the 15th; the lowest, 28.50 inches, on the 7th. At Midway Island pressure was above normal, the average for the month being 30.06 inches, as compared with a normal of 30.01 inches. The highest pressure, 30.20 inches, occurred on the 15th; the lowest, 29.88 inches, on the 27th. At Honolulu the departure from normal was very small, being, approximately, +0.01 inch. The average pressure for the month, based on a. m. and p. m. observations, was 30.01 inches. The highest, 30.08 inches, occurred on the 2d; the lowest, 29.89 inches, on the 28th.

Fog was reported on several days, most frequently in high latitudes east of the 180th meridian. There was a considerable decrease in its observance over that of September.

NOTES ON WEATHER IN OTHER PARTS OF THE WORLD.

Mexico.—MEXICO CITY, October 22.—Reports received here from Vera Cruz, Progreso, Tampico, Tuxpan, and other ports indicate that the storm which has swept the Gulf of Mexico during the last few days has done considerable damage to shipping. Several small vessels were sunk.

The Ward liners *Esperanza* and *Morro Castle* are still outside Vera Cruz unable to enter the harbor after having fought the waves for two days.—*New York Herald, October 23, 1922.*

MEXICO CITY, October 13.—The cold wave which has persisted in the Valley of Mexico for the past two days has seriously damaged the corn and bean crops, according to the reports received by the department of agriculture. In some places ice is said to have formed—an almost unheard-of condition here.—*Washington Evening Star, October 13, 1922.*

France.—CHERBOURG, October 29.—The worst Atlantic storm in years, with blinding snow and winds, is delaying all steamships in and out of Cherbourg. The wind and heavy seas in the harbor caused the steamship *Welcome* to collide with the United States liner *President Polk*, damaging the former. The *Saxonia* is two days late, and the *President Harding* is reported damaged by the tempest at Queenstown.

The *Homeric* was forced to seek the protection of the sea wall in order to disembark the passengers, who report an extremely rough passage. The steamship *Wisserling*, from the United States, will be required to remain in Cherbourg for repairs.—*Washington Post, October 30.*

British Isles.—October was generally cold and fairly dry in most parts of England, with a large amount of easterly wind, and was in marked contrast to the warm and bright weather experienced in the corresponding month of last year.—*Nature, London, November 4, 1922, p. 612.*

Italy.—ROME, October 20.—Rome and the surrounding region was suffering to-day from the effects of an unusually severe storm which lasted 30 hours, and during which lightning caused several fires and the heavy rainfall flooded basements in various parts of the city.

The Tiber overflowed its banks outside the city, inundating a considerable extent of the countryside, driving hundreds of families out of their homes and putting the railway line between Rome and Pisa out of commission.—*Washington Evening Star, October 20.*

Russia.—RIGA, October 22.—The Russian armored cruisers *Rossiya* and *Gromoboi* and several other vessels have been lost in a storm in the Baltic Sea.—*New York Herald, October 23.*

India.—CALCUTTA, October 4.—Floods in northern Bengal have taken an enormous toll of life, according to passengers on the first train to reach here from Darjeeling in eight days.

It is impossible to estimate the extent of the disaster at present, but the travelers estimate that several thousand persons have been drowned in the affected area, other thousands made homeless and destitute, and valuable crops destroyed. The floods are said to be the worst in the history of Bengal.

Many refugees are living in hovels constructed on high land. An outbreak of cholera is adding to the difficulties of the relief workers.—*Washington Evening Star, October 4, 1922.*

Hawaii.—HONOLULU.—Hawaii, "land of sunshine," has just enjoyed what the sugar planters of the islands are happy to refer to as a "million-dollar rain." The downpour, torrential on many of the islands, lasted for almost 12 hours, and, coming as it did at a critical season of the year for sugar, brought untold relief to those who have invested their principal capital in the chief staple of the Territory. As a result of the rain the planters predict an increase in valuation of the sugar crop which may multiply the million-dollar mark several times over.—*Chicago Tribune, October 22, 1922.*

DETAILS OF THE WEATHER IN THE UNITED STATES.

GENERAL CONDITIONS.

By A. J. HENRY.

As a whole, the month was characterized by cyclones that lacked in intensity, by anticyclonic movement with a larger than usual southerly component of motion, and by dry weather in the great majority of districts.

CYCLONES AND ANTICYCLONES.

By W. P. DAY.

No really important storms were charted within the area of the United States proper, although one or two good blows occurred on the North Pacific coast, the Lake region, and the North Atlantic coast, and disturbed conditions prevailed over the Gulf of Mexico during a large part of the month. The influence of the hurricane which traversed the northern portion of the Province of Yucatan in Mexico was not felt north of the Tropics.

High-pressure areas were about normal in number, movement, and with respect to place of origin.

Tables showing the number of cyclones and anticyclones by types are given below. Two storms of tropical origin are not included, though shown in part on Chart II.

Cyclones.	Alberta.	North Pacific.	South Pacific.	Northern Rocky Mountain.	Colorado.	Texas.	East Gulf	South Atlantic.	Central.	Total.
October, 1922	4.0	2.0	....	2.0	1.0	1.0	2.0	1.0	1.0	14.0
Average number, 1892–1912, inclusive	4.2	1.3	0.7	0.5	1.7	0.7	0.4	0.5	0.3	10.3

Anticyclones.	North Pacific.	South Pacific.	Alberta.	Plateau and Rocky Mountain. region.	Hudson Bay.	Total.
October, 1922	4.0	....	4.0	....	1.0	9.0
Average number, 1892–1912, inclusive	2.8	0.9	3.0	1.2	0.6	8.5

FREE-AIR CONDITIONS.

By L. T. SAMUELS.

Free-air temperatures during the month were mostly above their normal values (Table 1). At Broken Arrow, Due West, and Ellendale these positive departures increased generally with altitude, while at Drexel they were only slightly smaller in the upper levels. At Groesbeck no appreciable change in the amount of the departures was found, while at Royal Center they were negative throughout, although considerably smaller in the higher levels. Comparison of surface departures with those given in Climatological Chart III shows good agreement with the exception of Royal Center. This apparent discrepancy is due partly to the short period available for which normals are computed and which, in this case, is obviously influenced to a greater degree than it should be by the unusually high mean for 1920, and in part to the smaller southerly component in the resultant winds as compared with the average for the month. (Table 2). It is of interest to note the direct connection between the wind direction and temperatures in the fact that on days when either record maximum or minimum temperatures for various levels were recorded the wind direction at the time had a southerly or northerly component, respectively.

Relative humidity departures were in general negative for all stations and levels, while those for vapor pressure conformed as a whole with the temperature departures.

In Table 2 are shown the resultant wind directions and velocities for the month and their averages. At the four stations having the largest positive temperature departures it will be noted that the resultant winds in most cases have either a greater southerly or a smaller northerly component than the average. The resultant winds at Groesbeck show a decidedly greater easterly component than normal.

At this time of the year winds begin to manifest characteristics of the winter season, particularly as regards increased velocities and less frequent easterly components at high altitudes. Pilot-balloon observations at numerous stations in the eastern and central sections of the country from the 18th to the 21st showed winds of hurricane velocity in the upper levels. Of particular interest during this period is the single-theodolite pilot-balloon observation made at Fort Bragg, N. C., on the morning of the 20th, when a velocity of 77 m. p. s. (172 m. p. h.) from the WNW. was observed at an altitude of 9,100 meters. The question of the reliability of the assumed ascensional rate upon which single-theodolite observations are necessarily based becomes at once of great consequence, and comparison with surrounding stations is of vital importance before accepting as correct such tremendous velocities. Simultaneous observations at the following stations showed velocities as follows:

Station.	Velocity.	Direction.	Altitude.
	m. p. s.		*m.*
Due West, S. C	42	W	8,400
Fort Benning, Ga	35	W	10,000
Mitchel Field, N. Y	42	WNW	4,000

Observations made just prior to, and shortly after, those given above, when extremely high upper velocities were general over this region, strongly substantiate the great velocity found at Fort Bragg on the 20th. This region was at the time under the influence of a widespread anticyclone, central to the northward, causing easterly winds in the lower levels. These winds became westerly above 3,000 meters and then increased greatly in velocity. The cause of these extreme velocities is plainly revealed on the weather maps for this period and is to be found in the sharp surface-temperature gradient extending from south to north. On the morning of the 19th it will be noted that this ranged from 28.9° C. in southern Florida to 1.1° C. in northern Mississippi. Such a temperature gradient obviously causes a steep south-to-north pressure gradient in the upper air on account of the difference in the resulting air densities and, when sufficiently steep, causes tremendous velocities such as were recorded. Reference is made to the pilot-balloon observation made at Lansing, Mich., on December 17, 1919, when a wind of 83 m. p. s. from the NW. was recorded at 7,200 meters elevation.[1]

[1] W. R. Gregg, MO. WEATHER REV., December, 1919, 47: 853–854.

Easterly winds to at least 4 and 5 kilometers observed generally over the central and eastern portions of the country during the first four days of the month seem significant in view of the fact that a large anticyclone remained practically stationary over the eastern half of the country during this period. Upper easterly winds were reported from several stations in the Gulf States from the 25th to the 30th, some of these extending above 10,000 meters. During this period the pressure distribution remained practically unchanged in the eastern half of the country.

At Madison on the 9th and 10th easterly winds were observed to 8,000 and 10,000 meters, respectively. These winds appear significant in view of the fact that a cyclone central on the morning of the 9th over Greenville, S. C., moved north-northwestward, increasing considerably in intensity by the morning of the 10th, and easterly winds at Madison to 10,000 meters on this date are evidence of the great height to which the effects of this depression reached.

On the morning of the 18th pilot-balloon observations at Washington and Bolling Field, D. C., showed a similarity, too striking to be caused by chance, of rather unusual wind conditions. It is evident from these observations that at least five successive air strata existed superimposed and having alternately higher and lower velocities, although with no appreciable change in direction. These conditions were apparent, though to a smaller degree, at both Aberdeen, Md., and Dahlgren, Va. The morning weather map for this date shows this region to have been on the dividing line between a strong anticyclone central over Oklahoma and an extensive cyclone to the northeast, central over New Brunswick. It is believed the alternating influence of these pressure systems produced the variation in velocities in this region.

The pilot balloon at Groesbeck on the morning of the 28th was followed with a single theodolite to an altitude of 23,000 meters. At the close of the observation another was immediately started, using two theodolites, during which the balloon was followed to 9,000 meters. To this height the agreement between the two was very close. Above this the observation must be accepted with reservation, but, with an ever-increasing number of observations, indications point strongly to a reliable assumed ascensional rate even in these higher layers, although nothing of a definite nature can be obtained until double-theodolite observations to these heights have been made. A general southwesterly direction was found throughout. The greatest velocity was 23 m. p. s. occurring at the highest altitude.

During the night of October 31–November 1 a tornado occurred in the extreme southwestern part of Missouri. One of the fundamental conditions for the development of tornadoes is a vigorous convection between strong neighboring countercurrents. That this condition occurred is obvious from the observations at this time. On the morning of the 31st Broken Arrow reported north surface winds with lower clouds moving from the south. Pilot-balloon and kite observations were impracticable in this region during the time immediately preceding the tornado, owing to the low clouds and abundant precipitation. However, it is evident from cloud observations that southerly and northerly winds were overrunning and existed adjacent to one another, and with unusually high temperatures occurring at the surface in this region violent convection ultimately set in.

An interesting feature during the month was the large number of days at Ellendale on which the electric potential recorded during kite flights exceeded 10,000 volts. This station reported this occurrence on 22 days out of the month, while none of the other stations reported similar phenomona occurring on more than 3 days.

TABLE 1.—*Free-air temperatures, relative humidities, and vapor pressures during October, 1922.*

TEMPERATURE (°C.).

Altitude, m. s. l. (m.)	Broken Arrow, Okla. (233m.)		Drexel, Nebr. (396m.)		Due West, S. C. (217m.)		Ellendale, N. Dak. (444m.)		Groesbeck, Tex. (141m.)		Royal Center, Ind. (225m.)	
	Mean.	Departure from 5-year mean.	Mean.	Departure from 7-year mean.	Mean.	Departure from 2-year mean.	Mean.	Departure from 5-year mean.	Mean.	Departure from 5-year mean.	Mean.	Departure from 5-year mean.
Surface..	17.4	−0.2	14.3	+2.4	16.0	−0.4	8.0	+0.1	19.1	−0.2	12.5	−1.7
250......	17.4	−0.1	......	......	15.8	−0.4	......	......	19.6	+0.5	12.5	−1.6
500......	17.3	+1.1	14.1	+2.5	14.5	0.0	8.6	+0.6	18.7	+0.6	12.0	−0.7
750......	16.1	+1.0	13.6	+2.9	13.6	+0.5	9.6	+1.8	17.7	+0.7	10.6	−0.8
1,000.....	14.3	+0.3	12.7	+2.7	12.7	+0.6	9.2	+2.0	16.5	+0.7	9.1	−1.1
1,250.....	12.9	−0.1	11.9	+2.5	11.6	+0.6	8.7	+2.3	15.2	+0.4	7.8	−1.2
1,500.....	11.7	−0.3	10.8	+2.3	10.8	+0.7	7.8	+2.2	13.8	+0.1	6.5	−1.3
2,000.....	9.7	−0.1	8.5	+2.4	9.0	+0.8	5.6	+2.3	11.2	−0.3	4.2	−1.3
2,500.....	7.5	+0.3	5.4	+2.0	7.1	+0.3	3.4	+2.7	8.9	−0.3	2.0	−1.1
3,000.....	4.9	+0.5	2.2	+1.6	4.9	+0.4	0.8	+2.9	6.9	−0.1	−0.7	−1.4
3,500.....	2.1	+0.5	−0.5	+1.6	2.7	+0.9	−1.7	+3.3	4.9	−0.1	−2.6	−0.7
4,000.....	−1.1	+0.2	−3.3	+1.5	1.1	+2.0	−3.7	+4.0	2.6	+0.1	−4.4	−0.4
4,500.....	−3.5	+0.6	−5.3	+1.6	−1.0	+2.0	−5.6	+4.9	−0.2	+0.3	−6.6	−0.4
5,000.....	−4.0	+2.6	−10.4	+1.6	−3.4	+2.0	−7.2	+6.0	......	......	......	......

RELATIVE HUMIDITY (%).

Surface..	55	−9	53	−7	69	+7	63	−3	64	−9	64	−3
250......	54	−10	......	......	69	+7	......	......	60	−11	63	−4
500......	49	−13	52	−7	65	+4	60	−4	55	−13	55	−9
750......	49	−12	50	−7	63	+3	53	−6	55	−12	54	−8
1,000.....	50	−9	49	−6	60	+1	51	−6	55	−11	53	−7
1,250.....	49	−7	48	−4	57	00	48	−6	54	−10	52	−6
1,500.....	48	−6	48	−3	51	−3	46	−5	54	−8	52	−4
2,000.....	44	−3	49	−2	44	−5	43	−6	55	−1	46	−5
2,500.....	43	+2	51	0	36	−6	39	−9	54	+4	42	−5
3,000.....	40	+3	51	+1	32	−7	38	−9	47	+4	41	−6
3,500.....	36	+1	44	−4	27	−9	38	−10	46	+7	37	−3
4,000.....	36	+3	43	−3	18	−15	35	−10	41	+6	23	−15
4,500.....	31	+1	43	−1	15	−15	35	−10	40	+4	22	−16
5,000.....	11	−14	43	−1	14	−15	37	−7	......	......	......	......

VAPOR PRESSURE (*mb.*).

Surface..	10.84	−2.15	8.69	+0.19	12.71	+0.95	6.39	−0.53	14.03	−2.66	9.28	−1.65
250......	10.79	−2.11	......	......	12.54	+0.91	......	......	13.36	−2.70	9.14	−1.65
500......	10.11	−1.56	8.45	+0.22	11.39	+0.88	6.41	−0.41	11.90	−2.08	7.77	−1.68
750......	9.41	−1.25	7.83	+0.79	10.52	+0.89	6.09	−0.33	11.18	−2.33	6.91	−1.52
1,000.....	8.56	−1.09	7.16	+0.65	9.56	+0.71	5.64	−0.26	10.35	−1.90	6.15	−1.50
1,250.....	7.72	−0.95	6.56	+0.65	8.32	+0.39	5.18	−0.15	9.38	−1.61	5.56	−1.30
1,500.....	6.93	−0.80	6.21	+0.78	6.98	+0.07	4.66	−0.12	8.60	−1.22	5.05	−1.02
2,000.....	5.41	−0.23	5.42	+0.87	5.31	−0.09	3.82	−0.09	7.40	+0.02	3.87	−0.82
2,500.....	4.52	+0.34	4.54	+0.89	3.78	−0.33	3.13	−0.13	6.45	+0.60	3.23	−0.44
3,000.....	3.56	+0.48	3.55	+0.69	2.97	−0.37	2.63	−0.03	5.21	+0.80	2.80	−0.18
3,500.....	2.84	+0.44	2.36	+0.16	2.14	−0.44	2.22	+0.04	4.55	+1.04	2.11	−0.32
4,000.....	2.37	+0.47	1.85	+0.12	1.32	−0.69	1.80	+0.14	3.63	+0.96	1.31	−0.48
4,500.....	1.87	+0.34	1.55	+0.16	1.01	−0.69	1.54	+0.28	3.53	+1.07	1.06	−0.53
5,000.....	0.96	−0.21	1.15	+0.16	0.76	−0.69	1.46	+0.49	......	......	......	......

TABLE 2.—*Free-air resultant winds (m. p. s.) during October, 1922.*

Altitude, m. s. l. (m.)	Broken Arrow, Okla. (233m.)				Drexel, Nebr. (396m.)				Due West, S. C. (217m.)				Ellendale, N. Dak. (444m.)				Groesbeck, Tex. (141m.)				Royal Center, Ind. (225m.)			
	Mean.		5-year mean.		Mean.		7-year mean.		Mean.		2-year mean.		Mean.		5-year mean.		Mean.		5-year mean.		Mean.		5-year mean.	
	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.	Dir.	Vel.
Surface	S. 8° W.	1.5	S. 5° W.	2.6	S. 24° W.	2.6	S. 30° W.	1.5	N. 44° E.	1.9	N. 39° E.	1.9	N. 53° W.	2.4	N. 58° W.	1.9	N. 52° E.	1.6	S. 44° E.	0.7	S. 48° W.	2.8	S. 41° W.	2.5
250	S. 7° W.	1.5	S. 4° W.	2.7	....	....	....	....	N. 44° E.	2.1	N. 39° E.	1.9	....	....	....	....	N. 62° E.	2.2	S. 30° E.	1.5	S. 50° W.	2.9	S. 41° W.	2.8
500	S. 13° W.	1.7	S. 12° W.	3.8	S. 28° W.	3.5	S. 33° W.	2.1	N. 54° E.	2.8	N. 43° E.	2.6	N. 54° W.	2.3	N. 61° W.	1.8	N. 70° E.	2.4	S. 13° E.	2.8	S. 61° W.	5.1	S. 51° W.	4.9
750	S. 23° W.	2.1	S. 17° W.	4.4	S. 39° W.	4.9	S. 46° W.	3.5	N. 67° E.	2.5	N. 53° E.	2.1	N. 73° W.	3.4	N. 67° W.	2.6	N. 81° E.	2.8	S. 5° E.	3.2	S. 77° W.	6.3	S. 59° W.	6.1
1,000	S. 33° W.	2.1	S. 24° W.	4.5	S. 51° W.	5.4	S. 58° W.	3.8	N. 78° E.	1.9	N. 54° E.	1.2	N. 78° W.	4.3	N. 69° W.	3.1	N. 80° E.	2.5	S. 3° W.	3.3	S. 79° W.	6.7	S. 65° W.	6.8
1,250	S. 31° W.	1.9	S. 35° W.	4.5	S. 60° W.	6.0	S. 63° W.	4.6	N. 85° E.	1.4	S. 84° E.	0.4	N. 81° W.	5.6	N. 75° W.	3.9	N. 84° E.	2.5	S. 13° W.	3.5	S. 86° W.	8.2	S. 67° W.	7.9
1,500	S. 40° W.	2.0	S. 43° W.	4.5	S. 65° W.	6.8	S. 71° W.	5.5	N. 75° E.	0.6	S. 48° W.	0.8	N. 77° W.	6.4	N. 79° W.	4.6	N. 56° E.	2.7	S. 25° W.	3.5	N. 85° W.	8.9	S. 72° W.	8.5
2,000	S. 52° W.	2.3	S. 50° W.	5.2	S. 68° W.	6.8	S. 79° W.	7.1	S. 54° W.	2.1	S. 68° W.	2.8	N. 77° W.	7.8	N. 79° W.	6.4	N. 34° E.	2.3	S. 45° W.	3.4	N. 84° W.	9.8	S. 75° W.	9.4
2,500	S. 69° W.	2.9	S. 61° W.	5.5	S. 80° W.	5.8	S. 81° W.	8.3	S. 66° W.	4.4	S. 81° W.	5.0	N. 77° W.	9.8	N. 77° W.	8.0	N. 36° E.	3.2	S. 57° W.	3.3	N. 79° W.	12.4	S. 80° W.	10.6
3,000	S. 85° W.	3.4	S. 69° W.	6.3	S. 76° W.	7.1	S. 85° W.	9.7	S. 65° W.	8.2	S. 80° W.	7.3	N. 68° W.	11.1	N. 78° W.	9.4	N. 42° E.	2.8	S. 63° W.	3.9	N. 76° W.	14.8	S. 83° W.	11.7
3,500	S. 64° W.	4.4	S. 70° W.	7.3	N. 85° W.	8.2	N. 86° W.	11.0	S. 76° W.	7.3	N. 89° W.	8.8	N. 75° W.	12.0	N. 83° W.	11.4	S. 73° E.	1.9	S. 50° W.	3.9	S. 89° W.	14.3	S. 83° W.	13.7
4,000	S. 43° W.	7.0	S. 65° W.	9.2	S. 89° W.	10.0	N. 88° W.	11.3	S. 71° W.	17.4	S. 70° W.	14.7	N. 83° W.	12.3	W.	11.8	S. 58° E.	5.7	S. 41° W.	2.8	N. 89° W.	15.4	S. 88° W.	13.0
4,500	S. 28° W.	8.9	S. 77° W.	10.2	S. 58° W.	8.6	N. 77° W.	11.3	N. 88° W.	17.0	S. 82° W.	14.2	N. 86° W.	14.2	S. 83° W.	13.4	N. 80° E.	9.1	S. 70° E.	4.0	S. 45° W.	24.0	S. 85° W.	16.3
5,000	S. 45° W.	8.8	S. 71° W.	11.5	S. 87° W.	5.6	N. 69° W.	8.5	N. 68° W.	16.8	N. 68° W.	16.7	N. 59° W.	17.3	N. 86° W.	14.4	....	....	....	....	S. 45° W.	26.2	S. 76° W.	20.2

THE WEATHER ELEMENTS.

By P. C. DAY, Meteorologist, in Charge of Division.

PRESSURE AND WINDS.

Compared with September the average pressure for October increases over all districts of both the United States and Canada, save from the Great Lakes eastward, where the increasing storm activity during October over the more stable conditions existing in September causes a general reduction in the average pressure in the district mentioned, as compared with the preceding month. In the far Northwest the permanent high-pressure area over the adjacent ocean during the warmer months of the year has usually advanced slightly inland by October, with the center of highest pressure over the interior portions of Oregon and Washington. Over the southeastern districts the permanent high pressure off the adjacent coast has likewise moved toward the land area and the center of highest pressure in October is usually over the southern Appalachian Mountain district.

During October, 1922, the areas of highest and lowest average pressure assumed nearly their normal locations, but the average pressure was on the whole below normal, this being particularly the case over the more easterly districts of both the United States and Canada. Over a narrow belt extending from the southern California coast to eastern Montana, western North Dakota, and the adjacent portions of the Canadian Northwest the average pressure was slightly above the normal.

Compared with the preceding month, the average pressure during October was decidedly lower, particularly from the Great Lakes eastward, where cyclonic disturbances were rather frequent during the last two decades. From the Great Plains westward the pressure during October, 1922, was higher than in the preceding month, but the excess was generally less than usually occurs.

Anticyclonic conditions existed over much of the country during the early part of the month; indeed, pressure was moderately high almost continuously over the districts from the Mississippi River westward until near the end of the month. As a result of this distribution of pressure, cyclones were confined mainly to the more eastern districts and even here they were mainly unimportant and occurred at infrequent intervals, save along the northern border from the Great Lakes eastward.

In the absence of important cyclones the air movement was moderate, and few damaging winds were reported.

Over the districts from the Mississippi River eastward the winds were mainly outward from the center of highest pressure, located over the southern Appalachian Mountains. In the Great Plains region they were largely from southerly points, except in the upper Missouri Valley, where they were from northwest to north. Over the districts to westward of the Rocky Mountains they were variable, as usual. A list of the comparatively few damaging windstorms of the month appears at the end of this section.

TEMPERATURE.

The outstanding feature of the weather during the month was the uniformly favorable temperature. Little uncomfortable cold occurred, and the changes from day to day were usually small.

The first decade of the month was nearly everywhere warmer than normal, the excess ranging up to as much as 12° per day in the middle Plains region. During this period the highest temperatures of the month were recorded in practically all portions of the country, and over the interior portions the highest ever observed in October were reported from numerous places.

At the beginning of the second decade an anticyclone of considerable magnitude was advancing into the upper Missouri Valley and the coldest weather of the season to date was reported from the adjacent Canadian Provinces. This anticyclone advanced rapidly southeastward during the following few days, attended by freezing temperatures as far south as Kansas and Iowa, and frosts were reported from portions of the Ohio Valley and Appalachian Mountain regions.

The week ending the 17th was on the whole colder than normal by several degrees over a wide area embracing most of the central valleys and southeastern districts. It continued slightly warmer than normal from the west Gulf coast northwestward to Oregon and Washington, and generally over the Northeastern States. The lowest temperatures of the month occurred during this week over large areas from the middle Plains northward to Canada.

For the week ending the 24th, temperatures continued generally below normal over the Great Lakes and in the Ohio and Mississippi Valleys, and cool weather extended over New England and into Texas and New Mexico. Over the Northwest and generally from the Rocky Mountains westward the averages for the week were above normal; the lowest temperatures of the month occurred during this period over most districts from the Mississippi River eastward and in portions of the southern Plains.

The closing week of the month was unseasonably warm over the great central valleys, and, except for small areas in the Northeast and over the far Southwest, the week was generally warmer than average over all portions of the country, the departures ranging up to as much as 18° in the middle Missouri Valley. The lowest temperatures of the month occurred, however, during the first day or two of this week over portions of the Gulf States and the last two or three days were the coldest of the month from the Rocky Mountains westward.

For the month as a whole average temperatures were above normal over all portions of the country, save over a narrow area from the Lake Erie region northeastward, along the immediate middle Gulf coast, and in the Great Valley of California. In Canada also the month was mainly warmer than normal, save over the northern portions of the Maritime Province and in the vicinity of Lake Superior.

Maximum temperatures were very generally above 90° on a number of dates during the first decade, reaching 102° in South Dakota on the 4th and 106° in Arizona on the 2d.

Freezing weather occurred in all the States except Florida, but in the Southeast only the more northern portions of the Gulf States and the elevated sections of the South Atlantic States had injurious frosts. On account of the warm and dry weather of the preceding month, which continued over so much of the country during October, all late crops were fully matured before injurious frosts occurred.

PRECIPITATION.

As was the case in the preceding month, precipitation was deficient over the greater part of the country; only a few of the States along the south Atlantic and east Gulf coasts and those bordering the Pacific had statewide averages appreciably above the normal.

Despite the general deficiency in the monthly totals, the rains were usually well distributed through the various parts of the month, so that in most sections no long periods were without some rain. However, drought existed during the latter part of September over extensive areas and this was not generally relieved until toward the latter part of the first decade in October over most northern and central districts. In portions of the western Plains and generally in the southern Rocky Mountain districts drought more or less severe has continued for several months, and the need of water and forage for stock was becoming serious.

On the other hand, unusually heavy precipitaion occurred in southern Florida, particularly in the Everglades, which were overflowed in certain sections to the depth of 2 to 3 feet, so fall crops were largely destroyed. Even outside the Everglades vegetables and citrus fruits were more or less damaged on account of flooded conditions.

The principal periods of precipitation were from the 6th to 9th over the districts from the Great Plains eastward, the falls during this period being quite heavy in the South Atlantic and Gulf States and portions of the Mississippi and Ohio Valleys.

Important rains occurred from the 9th to 11th over the more eastern districts, some heavy local falls occurring over the Atlantic coast. In the vicinity of Baltimore torrential rains occurred during the night of the 9th–10th, the amounts measured at the Weather Bureau station in Baltimore exceeding any previous record for a similar period, 5.18 inches falling in slightly more than eight hours.

Another rainy period set in over the Southeastern States on the 12th and extended northward along the Atlantic coast for several days. Over much of Florida rain was more or less continuous and at times heavy for a week or more about this time.

During the latter part of the month precipitation was mostly light and scattered, although there were beneficial rains over wide areas from the Mississippi Valley eastward on the 23d–24th, and some heavy local falls in Texas and to the northward at the end of the month.

Over Florida, over the Atlantic Coast States as far north as Virginia, and in portions of the Gulf States the total precipitation for the month ranged from 4 to 6 inches or more. In other districts from the Great Plains eastward the amounts were usually less than 2 inches, with occasional amounts exceeding 4 inches. Over the greater part of the western Plains, the Rocky Mountains, and Plateau States the total falls were less than one-half inch, and practically no rain fell over large areas of the southern portions of those regions.

The maximum fall during the month was 23.89 inches, at Homestead, Fla.

SNOWFALL.

In most high portions of the mountain districts of the West there was some snowfall during the month, but scarcely anywhere were the falls notable for the time of year. In parts of the Plateau region, and in central and northeastern Wyoming, the Black Hills district, eastern Montana, and much of North Dakota there was considerable snow during the last few days of the month, also from North Dakota to the vicinity of Lake Superior there was moderate snowfall about the 16th or 17th. Otherwise the snowfall of the month was unimportant.

RELATIVE HUMIDITY.

In nearly all portions of the country, even in some where there was a moderate excess of precipitation, the relative humidity was less than normal. The humidity was especially less than normal in the Plateau, Rocky Mountain, and Plains regions, and was somewhat less in the west Gulf area, the central valleys, and the Northeast. In Florida and the east Gulf States, however, there was slightly greater humidity than usual in October, and excess is noted also in the Pacific Northwest and northern California.

SEVERE LOCAL STORMS.

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the annual report of the chief of bureau.]

Place.	Date.	Time.	Width of path (yards).	Loss of life.	Value of property destroyed.	Character of storm.	Remarks.	Authority.
Elizabethton, Tenn	7					Wind, rain, and hail.	Houses blown from foundations; trees and telephone poles blown down.	Official, U. S. Weather Bureau.
Duval County, Fla	17-18					Northeast gale	High tides and waves on coast destroy bulkheads and damage cottages and piers.	Florida Times-Union (Jacksonville).
Connecticut coast	23	P. m.				Thundersquall, with hail.	Church steeple and barn wrecked and windows blown in at Milford; minor damage elsewhere along coast.	Courant (Hartford, Conn.); Republican (Springfield, Mass.).
New York, N. Y	26	4.40 p. m.		1		Wind	Heavy sign blown down; 5 people injured	New York Herald (N. Y.).

STORMS AND WEATHER WARNINGS.

WASHINGTON FORECAST DISTRICT.

Unsettled weather conditions prevailed over the Gulf of Mexico and the northwestern Caribbean during a large portion of the month and several disturbances of importance were charted, in contrast to the lesser activity on the Atlantic seaboard.

At 10 p. m. of the 2d northeast storm warnings were displayed on the east Gulf coast from Bay St. Louis, Miss., to Cedar Keys, Fla., in connection with a disturbance of moderate intensity that developed over the northeastern Gulf of Mexico and moved slowly westward. It gradually lost intensity and apparently dissipated on the 4th. The lowest barometer reading reported was 29.72 inches at Burrwood, La., and the highest wind velocity, 32 miles an hour from the east at Pensacola, Fla.

On the evening of the 7th a disturbance of marked intensity was central over Lake Erie, moving northeastward, and storm warnings were ordered displayed at 10 p. m. from Delaware Breakwater to Eastport, Me. The following morning the storm warnings were changed to small-craft warnings, the storm having decreased in intensity during the night. The highest wind velocity reported was 48 miles an hour from the south at Atlantic City, N. J.

Small-craft warnings were displayed from Delaware Breakwater to Nantucket, Mass., on the 10th; from Baltimore, Md., to Eastport, Me., on the 23d; from Delaware Breakwater at Eastport, Me., on the 25th; and from Cape Hatteras to Nantucket, Mass., on the 26th.

At 9:30 p. m. of the 12th the first advisory warning was issued regarding the disturbance that formed east of Swan Island in the northwestern Caribbean Sea and moved slowly northwestward during the 12th-17th, inclusive. Frequent special observations by radio from the S. S. *Chalmette* on the 15th were of great assistance in locating the center of the disturbance on that date. Storm warnings in connection with this disturbance were displayed as follows: 9 p. m. of the 13th, Punta Gorda to Jupiter, Fla.; 8 a. m. of the 14th, north of Punta Gorda to Tarpon Springs, Fla.; 10 p. m. of the 14th, Cedar Keys, Fla., to Bay St. Louis, Miss. The highest wind velocity at a land station was 32 miles an hour from the east at Key West, Fla., on the 14th; while the S. S. *Ellis* reported 48 miles from the northeast on the 14th in latitude 25° 12′ N., longitude 85° 42′ W., and the S. S. *Chalmette* reported 48 miles from the west on the 15th in latitude 26° 00′ N., longitude 85° 42′ W. After its center reached latitude 28° N., this disturbance turned toward the northwest and decreased in intensity, passing inland between Pensacola, Fla., and Mobile, Ala., as a very slight disturbance, on the morning of the 17th.

On the evening of the 15th the first advisory warnings were issued in connection with another tropical disturbance that apparently developed immediately southwest of Jamaica on the 14th and moved slowly west-northwestward to the northern portion of the Yucatan Peninsula, thence southwestward over the extreme eastern portion of the Gulf of Campeche to the Mexican coast in the vicinity of Frontera, where it was apparently central on the morning of the 21st. This storm dissipated after moving inland, but heavy rains continued for a day or two longer over the eastern States of Mexico.

The lowest barometer reading reported during this storm was 29.06 inches, by the S. S. *Ceiba*, in latitude 20° 12′ N., longitude 87° 6′ W., on the morning of the 18th, at which time the wind was blowing 64 miles an hour from the south. On the 20th the S. S. *Hibueras*, in latitude 20° 10′ N., longitude 92° 06′ W., reported a wind of force 12 from the northeast. The lowest barometer reading reported by this vessel was 29.42 inches.

The following press dispatch from Mexico City, dated October 22, was published in the morning papers of October 23.

> Reports received here from Vera Cruz, Progresso, Tampico, Tuxpan, and other ports indicated that the storm which has swept the Gulf of Mexico in these regions during the past few days has done considerable damage to shipping. Several small vessels were sunk. The Ward liners *Esperanza* and *Morro Castle* are still outside Vera Cruz unable to enter the harbor after having fought the waves for two days.

Later press reports refer to an urgent call for help having been received from the governor of Quintana Roo, eastern Province of Yucatan, who telegraphed that the entire coast had been lashed by a severe storm, destroying property and crops and causing some loss of life. The islands of Mujeras and Cozumel, off the northeastern coast of Yucatan, were reported to have been swept bare. Newspaper dispatches from Yucatan reported the foundering of several small vessels.

The fishing smack *Ida S. Brooks* was caught in the storm north of Cozumel Island, the eye of the storm passing very nearly over her, as indicated by the distinct lull noted between a whole gale to hurricane from the north, shifting to a full hurricane velocity from the southeast. The sloop was carried northward over the reefs, bumping many times, and finally wrecked on Contoy Island, where the crew managed to get ashore. They were taken off three days later by the S. S. *Hibueras*, which had ridden out the storm in the Gulf of Campeche.

The following letter, dated October 27, 1922, from the manager of the Marine Department, Standard Oil Co. of New Jersey, tells of the use made by that corporation of the advices issued by the Weather Bureau in connection with the storm of the 14th-21st.

> During the hurricane in the Yucatan Channel and the Gulf of Mexico last week a number of our steamers were in close proximity to the center of this disturbance.

Due largely to the accurate and prompt information which we received daily from your office and Mr. Kimball, of your New York office, we were able to keep the masters of our vessels fully advised of the course this storm was taking, thus enabling them to keep clear of the center of the storm and perhaps preventing the loss of both life and property.

We wish to take this opportunity of expressing to you our thanks for the valued services rendered, which are greatly appreciated.

The highest wind velocities reported from Mexican stations were 60 miles from the northwest at Vera Cruz and 56 miles from the northwest at Puerto Mexico on the 20th. Reports from stations farther east were missing. Advisory warnings in connection with this storm were issued twice daily until the 21st. The radio reports received from ships were invaluable, especially the regular and special reports from the steamers *Zacapa*, *Hibureas*, and *Ceiba*, without which reports it would have been impossible to have reported the course of the storm accurately.

A communication concerning the meteorological conditions in the Canal Zone preceding and during the formation of these two disturbances of the 12th-17th and the 14th-21st, and the uses to which the storm advices were put, has been received from Mr. R. Z. Kirkpatrick, Chief Hydrographer, Canal Zone. The following are extracts from the letter:

Reference is made to the recent predictions on the West Indian hurricanes, which were promptly received by cable and via Swan Island. These messages were broadcast by radio and by notices to mariners, as fast as received here. They were instrumental in causing some of the boats in the New Orleans trade to postpone their sailings for a day or two. So far, not many marine casualties have been reported.

* * * * *

The few days preceding the appearance of the first disturbance in the Caribbean on the 12th were accompanied by an unusually low barometer on the Canal Zone, the average pressure for the 11th being 29.79 inches. By the 14th this average had increased to 29.87 inches. Southerly winds prevailed from October 8 to 17, inclusive. In the early morning of the 13th a strong wind was experienced on the Pacific coast, attaining a maximum velocity of 36 miles per hour shortly after noon of the same date. An unusual total wind movement of 425 miles was recorded at Balboa Heights on this date, but by midnight the velocity had decreased to 3 miles per hour; then local influences caused a short period of north wind, which later changed to south again at daybreak. This southerly blow, although experienced at Balboa Heights and Cape Mala, was not very pronounced at Cristobal.

* * * * *

The canal and shipping interests appreciate the prompt service given by the Weather Bureau and the Swan Island radio.

It will be noted that the wind direction and movement were unusual, being from the south from the 8th to the 17th, inclusive. A similar radical departure from the normal wind régime occurred in October, 1921, preceding the formation over the southwestern Caribbean of the hurricane of that month.

In connection with this, reports have come out of the Magdalena Department of Colombia of a storm which swept that region during the 48 hours between October 10 and 11, with great destruction to the banana plantations. The connection between this storm and the disturbance noted over the western Caribbean on the 12th seems obvious.

From the 26th to the 29th, inclusive, advisory warnings were issued daily in connection with a disturbance that appeared south of the Louisiana coast on the morning of the 26th and moved slowly eastward with diminishing intensity and another that moved northward from the central Gulf during the 28th-30th, passing inland on the Mississippi coast on the latter date. Small-craft warnings were displayed from Mobile, Ala., to Cedar Keys, Fla., on the 29th. The highest wind velocity reported was 40 miles an hour from the east at Pensacola, Fla., on the 29th.

Frost warnings were issued for a considerable area in the Washington forecast district on the following dates: 12th, 13th, 17th, 18th, 19th, 20th, 23d, 24th, and 26th. These warnings were well verified, as a rule. No warnings were issued, however, for sections farther south than central Mississippi, northern Alabama, northern Georgia, and South Carolina.—*Chas. L. Mitchell.*

CHICAGO FORECAST DISTRICT.

At the beginning of October killing frost has been experienced over only a few areas in the district, but by the close of the month it had occurred southward almost to the southern limits, the exceptions including southwestern Kansas, southeastern Missouri, extreme southern Illinois, and the region immediately surrounding southern Lake Michigan. Frost warnings were issued from time to time as the occasions seemed to require, and, in the main, and including the more important occurrences, they were verified. The dates on which warnings were disseminated follow: 2d, 4th to 12 inclusive, 14th, 16th to 19th inclusive, and 23d. Those issued on the 11th, 12th, 16th, 17th, and 18th were the most general in both scope and importance. Frost warnings for the Wisconsin cranberry interests were discontinued with those issued on the 2d.

On the Great Lakes the first decade of October was quiet, no winds of storm force occurring. The remainder of the month, however, showed a marked increase in storm activity, expecially over the extreme eastern portions of Lakes Erie and Superior and northern Lake Huron. At Buffalo, N. Y., wind velocities of verifying force occurred on five dates and at Alpena, Mich., on four dates.

The first storm warning for the month was issued on the afternoon of the 13th in connection with a disturbance that was moving rapidly eastward over northern Minnesota, southwest warnings being ordered for all upper Lakes stations, excepting Duluth, Minn. Although the disturbance decreased in strength as its center passed eastward immediately north of the upper Lakes, nevertheless verifying velocities occurred over northern Lakes Huron and Michigan and eastern Lake Superior.

On the afternoon of the 16th a weak disturbance of the Alberta type that had reached the Lake region increased considerably in energy, and during the ensuing 24 hours moved rapidly northeastward to the mouth of the St. Lawrence River. Winds of storm force, mostly from the northwest, were attained within the following 36 hours on the eastern shore of Lake Michigan, over the extreme eastern portions of Lakes Erie and Superior, and on Lake Ontario. At the morning observation of the 18th northwest warnings were issued for Lakes Huron and Ontario, eastern Lake Erie, and extreme eastern Lake Superior, but these were lowered a few hours later when it seemed apparent that the gradient was about to decrease rapidly. However, there was a redevelopment over Ontario, Canada, on the night of the 18th-19th that resulted in a maximum velocity of 56 miles an hour from the west at Buffalo, N. Y., on the 19th.

On the morning of the 23d a distubance of considerable intensity was central north of Lake Ontario. Northwest warnings were issued for Lake Ontario, and southwest warnings for Lake Erie from Dunkirk to Tonawanda, the latter by the Buffalo, N. Y., official. Likewise, the Alpena, Mich., official issued northwest warnings at 10:30 a. m. for the Alpena section of Lake Huron. All these warnings were verified.

On the morning of the 24th a disturbance had reached Manitoba with central pressure of 29.32 inches. In the early afternoon southwest warnings were issued for all upper Lakes station, except northwest at Duluth Minn., and at 4 p. m., for Lake Erie. At 10 p. m. the warnings were extended to Lake Ontario. In general these warnings were verified, but in most cases the wind did not become strong until the center of the depression had passed to the eastward, the winds being from the northwest.

On the morning of the 28th northeast warnings were issued for Lake Superior from Duluth to Munising. The warning was verified at Duluth. A similar warning was ordered for Duluth only on the night of the 29th, but this warning was lowered on the following morning when it had become apparent that the depression over the plains states was decreasing in strength.

Small-craft warnings were advised on the 4th for central and eastern Lake Superior and northern Lake Huron, and were issued by the Houghton official on the 11th and 21st and by the Ludington official on the 24th.

A special week-end forecast for Milwaukee and vicinity, prepared on Thursday mornings, was begun in October. This service is in response to the increasing demand that the regular forecasts be extended, expecially to cover the week end, when the forecasts are a matter of much interest to those who take pleasure trips.

A second long-range forecast is also now being prepared for publication in the Wisconsin State Journal at Madison, Wis. This is made on Tuesdays and attempts to cover the conditions expected during the remainder of the week.

Special flying forecasts for zone 4 were sent to Selfridge Field in connection with the aviation meet held on October 13–15 and two special long-range forecasts, covering general weather conditions, were furnished the Detroit office.

The usual temperature forecasts for a week in advance and covering conditions in Montana and North Dakota were begun to the Wenatchee Valley Traffic Association on Monday, October 23. These forecasts were a feature of the work of this office during the last two winters, and are used by the association in connection with their fruit shipments to the East.—*Charles A. Donnel.*

NEW ORLEANS FORECAST DISTRICT.

Northeast storm warnings were displayed, 9 a. m., October 3, from Morgan City to Salmen, La., in connection with a disturbance in the middle Gulf. Small craft warnings were issued for the Texas coast, 9:30 a. m., October 17. Storm warnings were ordered for the Texas coast, Port Arthur to Velasco, and small-craft warnings for the remainder of the Texas coast, 9 a. m., October 23, 1922. Small-craft warnings were ordered, 9:20 a. m., October 25, for the Texas coast. Storm warnings were ordered 12:30 p. m., October 26, for stations at the mouth of the Mississippi River and small-craft warnings for the remainder of the Louisiana coast and the Texas coast, Port Arthur to Galveston. These warnings were generally justified by the subsequent conditions, notwithstanding storm winds did not occur at the stations named. No storm occurred without warnings.

Frost warnings were issued October 7 for the northern portion of Oklahoma and the Texas Panahandle; on the 8th, for northern Oklahoma; on the 10th, for northern Arkansas; on the 11th, for northern Oklahoma and northwestern Arkansas; on the 12th, for northern Arkansas; on the 17th, for Arkansas, Oklahoma, the northern portion of west Texas, and the northwestern portion of east Texas; on the 18th, for Arkansas and Oklahoma; on the 23d, for Arkansas, Oklahoma, the northern portion of Texas, and northwestern Louisiana; on the 31st, for Oklahoma, west Texas, and the northwest portion of east Texas. These frost warnings were generally verified, and no frost of extent occurred without warnings.

"Norther" warnings were issued for Tampico, Mexico, October 17 and 23.

Fire-weather warnings were issued for Oklahoma, October 16.—*I. M. Cline.*

DENVER FORECAST DISTRICT.

Unusually dry weather, amounting to a drought in large areas, continued in the Denver forecast district during October, and the temperature for the month, as a whole, was considerably above the normal. Low temperatures, with frosts, occurred, however, on several dates. Timely warnings were issued, except for Modena, in extreme southwestern Utah.

The first freezing temperature warnings of the season for places in the fruit valleys in western Colorado were issued on the morning of the 6th. Temperatures as low as 27° were reported on the morning of the 7th in the Gunnison Valley. Warnings of heavy-to-killing frost were issued for Colorado and northern New Mexico on the 7th, with freezing temperature in localities in Colorado and possibly light frost in southeastern New Mexico. Heavy-to-killing frost was reported in northeastern Colorado and freezing temperature occurred in the greater part of the State.

On the 13th a trough of low barometer extended northeastward across Colorado to the Red River Valley of the North, and the barometer was rising in northwestern districts. A freezing-temperature warning for the fruit valleys of western Colorado was issued on the 13th and 14th, and was fully justified. An anticyclonic area from Alberta was moving rapidly southeastward over eastern Montana on the 16th, and the first warning of freezing temperature for eastern Colorado and northern New Mexico was issued on this date. Freezing temperature occurred as forecast, and killing frost, with freezing temperature, was reported on the eastern slope and as far south as Santa Fe. Freezing-temperature warnings were repeated for Colorado and northern New Mexico on the 17th to southeastern New Mexico, and frost was forecast for Utah. Freezing temperature or frost was reported, except in southeastern New Mexico, where a temperature of 36° occurred, with frost. Another trough of low barometer extended from New Mexico northeastward to Minnesota on the 21st, with a well-defined anticyclonic area in the north Pacific States. Freezing temperature or frost warnings were issued for Colorado and northern New Mexico on the 21st and 22d. The warnings were fully justified.

Warnings of freezing temperatures were issued for western Colorado, northwestern New Mexico, and Utah on the 28th. Freezing temperature occurred in localities in the region mentioned, with a temperature of 24° at Santa Fe and Albuquerque, and a killing frost was reported at the latter station. High pressure continued to spread slowly southeastward and the warnings were extended to northeastern Colorado and northern Arizona on the 29th and to southeastern Mew Nexico on the 30th, with possibly frost in south central Arizona. Temperatures of 20° to 24° occurred in the Gunnison Valley on

the morning of the 31st, 8° above zero was reported at Flagstaff, and the temperature fell below the freezing point at Roswell for the first time during the season, with a killing frost. The first heavy frost was reported at Salt Lake City, with a temperature of 34°. Warnings of freezing temperature were repeated on the 31st for southwestern Colorado and Utah, with possibly frost in south-central Arizona. Freezing temperatures occurred in these districts on November 1, and frost temperatures were reported at Phoenix on the mornings of October 31 and November 1.—*Frederick W. Brist.*

SAN FRANCISCO FORECAST DISTRICT.

During the greater portion of the period from the 1st to the 23d, high-pressure areas prevailed over the region between southeastern Alaska and th State of Washington. The Aleutian low-pressure area was pronounced during the entire month and on several occasions the barometer fell below 29 inches. None of the offshoots from this center of action succeeded in getting clear of the high-pressure barrier until late in the month, and then their energy was greatly diminished before crossing the Coast Range.

Storm warnings, however, were necessary at northern seaports on the 4th–5th, 24–25th, and 29th and along the California coast on th 9th and 26th. Although the wind at the stations where the storm warnings were displayed did not become very high, the gales were undoubtedly severe a short distance offshore.

Frost warnings were issued on several occasions for the States of Nevâda, Idaho, and for the east portions of Washington and Oregon. These predictions were generally correct, and by the end of the month the growth of vegetation has ceased throughout this large area and no more warnings will be needed in that section until next spring.

Rain warnings were issued in California sufficiently in advance of every storm to enable those drying fruit in the open to stack their trays in time to prevent losses. The few losses that did occur through neglect or lack of help were an insignificant fraction of the crops involved as compared with the total output.—*E. A. Beals.*

RIVERS AND FLOODS

By H. C. FRANKENFIELD, Meteorologist.

There was no change in the prevailing low-water conditions, and there were no floods, except in the Santee River, where there were moderate floods from October 19 to 24, inclusive, from the heavy rains that fell on October 16 and 17. The swamps and adjacent lands have been flooded since the winter of 1921–22, and consequently there was no damage done.

Flood stages during October, 1922.

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
ATLANTIC DRAINAGE.					
Santee:	*Feet.*			*Feet.*	
Rimini, S. C.	12	19	22	13.3	20
Ferguson, S. C.	12	20	24	12.7	23

MEAN LAKE LEVELS DURING OCTOBER, 1922.

By UNITED STATES LAKE SURVEY.

[Detroit, Mich., November 6, 1922.]

The following data are reported in the "Notice to Mariners" of the above date:

Date.	Lakes.[1]			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during October, 1922:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	602.50	579.97	571.86	245.61
Above or below—				
Mean stage of September, 1922	−0.19	−0.36	−0.47	−0.42
Mean stage October, 1921	−0.03	+0.11	+0.07	+0.50
Average stage for October, last 10 years	−0.22	−0.57	−0.33	−0.26
Highest recorded October stage	−1.06	−2.97	−1.84	−2.20
Lowest recorded October stage	+0.92	+0.37	+1.06	+1.94
Average relation of the October level to:				
September level		−0.20	−0.30	−0.30
November level		+0.20	+0.20	+0.20

[1] Lake St. Clair's level: In October, 574.69 feet.

INFLUENCE OF WEATHER ON CROPS AND FARMING OPERATIONS.

By J. WARREN SMITH, Meteorologist.

October, 1922, was mild for the season in all sections of the country, with scanty precipitation in most districts. Freezing weather extended during the week ending on the 24th as far south as southwestern Kansas, northwestern Arkansas, and southwestern Ohio, but no widespread damage occurred, as crops were mostly harvested or fully matured. Considerable local damage, however, occurred to grapes in the Chautauqua belt in New York during that week. The month was favorable as a rule for maturing late crops and for outdoor operations, and farm work made good advance, except where the soil was too dry for plowing and seeding. It was especially favorable for the harvest of corn in practically all sections, and at the close of the month cribbing was well under way, although it was rather too warm for storage in large quantities in some interior States, particularly in Iowa. Late corn made rather unsatisfactory growth in the central Gulf districts because of lack of rainfall.

At the beginning of the month there was a serious lack of moisture in much of the Great Plains and the Southwest which was unfavorable for seeding winter grains, and the drought was intensified during the first half of October by persistent absence of precipitation. Droughty conditions east of the Mississippi, however, were largely relieved in the Central and Eastern States by good rains about the 7th of the month. The increased moisture was very beneficial to early sown grains and facilitated seeding which had become backward. The latter half of the month was mostly favorable in the eastern grain States, but very little rain fell in the western Plains area, where wheat continued to suffer. The drought was broken in most of Texas and Oklahoma the latter part of the month, and at the same time rains and snows were beneficial in the central Rocky Mountain States.

Fair and moderately warm weather was the rule in the Cotton Belt and picking and ginning made unusually rapid progress. The weather was favorable for the development of late cotton in North Carolina, which turned out well; but, on the whole, conditions were unfavorable for top crop in nearly all sections of the belt and very little was produced. At the close of the month cotton was nearly all gathered in Tennessee and picking

was completed in many localities in Arkansas and was well advanced in the more northwestern portion of the belt.

Satisfactory progress was made in the harvesting of white and sweet potatoes and sugar beets under mostly satisfactory weather conditions. There was too much rain in the trucking districts of the Southeast, particularly in Florida, where much lowland was under water, but there was some improvement during the latter part of the month and planting winter truck was resumed.

Pastures were generally poor because of drought in Oklahoma and were practically gone at the end of the month in much of Kansas, while the range continued poor to bare in New Mexico and was much too dry in Arizona. There was sufficient precipitation to benefit ranges, however, in most other western grazing sections, while the rainfall the last half of the month was helpful in most districts east of the Mississippi River, although it continued too dry in some sections.

CLIMATOLOGICAL TABLES.[1]

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, October, 1922.

Section.	Temperature.								Precipitation.					
			Monthly extremes.								Greatest monthly.		Least monthly.	
	Section average.	Departure from the normal.	Station.	Highest.	Date.	Station.	Lowest.	Date.	Section average.	Departure from the normal.	Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	65.3	+ 0.5	Tuscaloosa	92	3	3 stations	32	[2] 19	2.56	− 0.42	Robertsdale	5.83	Healing Springs	T.
Arizona	63.2	+ 1.2	2 stations	106	2	Lakeside	3	30	0.31	− 0.56	Fort Valley	1.63	17 stations	0.00
Arkansas	63.1	+ 0.8	Rison	98	4	2 stations	20	18	1.47	− 1.53	Pindall	4.35	Arlberg	0.15
California	59.7	− 1.1	Greenland Ranch	103	2	Madeline	13	30	1.51	+ 0.23	Twin Valley	6.75	6 stations	0.00
Colorado	47.2	+ 1.3	Lamar	99	4	Dillon	− 1	30	0.45	− 0.83	Yampa	1.43	15 stations	0.00
Florida	74.5	+ 1.3	Orlando	96	7	Garniers	38	5	8.28	+ 3.73	Homestead	23.89	Wausau	1.50
Georgia	65.9	+ 1.1	Hazlehurst	94	8	Blue Ridge	28	27	3.73	+ 0.91	St. George	8.67	Concord	1.29
Hawaii	73.8	+ 0.3	Kaueleau No. 2, Hawaii.	91	[2] 9	Volcano Observatory, Hawaii.	50	9	5.44	+ 0.23	Eke, Maui	27.00	Olowalu, Maui	0.03
Idaho	49.5	+ 3.3	Deer Flat	94	[2] 1	Warren	4	30	0.71	− 0.63	Sandpoint	4.58	Challis	0.00
Illinois	58.5	+ 3.3	Carbondale	96	3	Freeport	22	18	2.28	− 0.30	Flora	5.76	Mount Carroll	0.13
Indiana	57.8	+ 3.2	Crawfordsville	98	6	Connersville	24	19	2.87	+ 0.17	Royal Center	4.83	Moores Hill	0.95
Iowa	56.1	+ 5.3	Guthrie Center	96	4	Little Sioux	14	17	1.81	− 0.65	Fayette	3.93	Davenport (Pine Acres).	0.06
Kansas	59.3	+ 2.8	Hutchinson	97	6	Smith Center	13	17	1.27	− 0.50	Winfield	3.87	2 stations	0.00
Kentucky	60.2	+ 2.4	2 stations	96	[2] 3	Greensburg	25	19	2.24	− 0.26	Blandville	4.41	Berea	0.76
Louisiana	68.1	+ 0.6	Dodson	95	[2] 1	Robeline	32	[2] 25	2.71	− 0.16	Abbeville	6.79	Logansport	0.01
Maryland-Delaware	58.4	+ 2.0	2 stations	93	5	Oakland, Md	15	31	1.88	− 0.99	Baltimore, Md	5.58	Aberdeen, Md	0.74
Michigan	50.0	+ 1.3	St. Joseph	94	[2] 4	Ewen	10	20	2.15	− 0.53	Ceresco	3.88	Eagle Harbor	0.39
Minnesota	49.4	+ 3.9	Ada	95	3	Wheaton	9	13	1.00	− 1.02	Fairmont	2.50	3 stations	T.
Mississippi	65.7	+ 1.0	2 stations	95	1	Batesville	31	19	1.63	− 0.95	Woodville	4.44	Okolona	0.38
Missouri	59.9	+ 2.4	Caruthersville	97	3	Dean	18	18	2.00	− 0.77	Grant City	3.83	Seligman	0.51
Montana	48.0	+ 4.0	2 stations	95	[2] 2	2 stations	8	[2] 16	0.58	− 0.57	Upper Yaak River	3.14	3 stations	0.00
Nebraska	54.7	+ 3.6	Newport	99	3	Curtis	5	17	0.63	− 0.93	Pawnee City	2.89	5 stations	0.00
Nevada	52.0	+ 1.3	Las Vegas	98	2	Rye Patch	4	30	0.32	− 0.27	2 stations	1.15	3 stations	0.00
New England	49.7	+ 1.3	Turners Falls, Mass	92	2	Garfield, Vt	10	19	2.54	− 1.00	Nantucket, Mass	5.34	Bethlehem, N. H	1.07
New Jersey	56.6	+ 1.6	3 stations	92	[2] 2	2 stations	18	21	1.48	− 2.25	Charlotteburg	2.70	Somerville	0.55
New Mexico	54.1	+ 0.6	Gage	98	[2] 4	Elizabethtown	− 3	31	0.34	− 0.90	Turney's Ranch	2.11	20 stations	0.00
New York	50.7	+ 0.4	Port Jervis	90	6	2 stations	8	[2] 18	2.47	− 0.96	Carmel	4.74	New York City	1.17
North Carolina	61.3	+ 1.2	2 stations	93	[2] 4	Banners Elk	22	13	4.50	+ 1.05	Sloan	8.34	Cullowhee	1.67
North Dakota	45.7	+ 1.9	Carson	98	3	2 stations	8	17	0.57	− 0.43	2 stations	1.70	3 stations	0.00
Ohio	55.8	+ 2.2	3 stations	93	5	Millport	21	19	1.78	− 0.89	Summerfield	3.43	2 stations	0.54
Oklahoma	63.3	+ 1.7	Hollis	98	3	2 stations	21	[2] 18	1.84	− 0.83	Fairfax	5.00	Kenton	0.01
Oregon	51.9	+ 1.4	Medford	88	7	Fremont	5	29	2.54	+ 0.42	Classic Lake	9.58	Harper	0.08
Pennsylvania	54.8	+ 2.5	3 stations	94	[2] 5	Wellsboro	12	21	2.51	− 0.80	Selins Grove	5.60	Neshaminy Falls	0.65
South Carolina	64.5	+ 0.9	Florence No. 1	94	[2] 4	Landrum	31	25	5.57	+ 2.48	Effingham	9.00	Orangeburg No. 2	3.04
South Dakota	50.9	+ 3.3	Colome	102	4	Lead	4	17	0.83	− 0.66	Fairfax	2.69	Oelrichs	T.
Tennessee	60.9	+ 1.2	2 stations	96	[2] 1	Mountain City	22	19	1.49	− 1.46	Mountain City	3.90	Florence	0.56
Texas	67.7	+ 0.2	San Benito	103	7	Dalhart	25	31	2.16	− 0.46	Matagorda	7.44	2 stations	0.00
Utah	50.7	+ 1.9	St. George	94	1	Great Basin Alpine	9	[2] 30	0.72	− 0.54	Kanosh	3.22	2 stations	T.
Virginia	59.4	+ 2.0	Lincoln	95	[2] 5	Burkes Garden	19	15	3.20	+ 0.11	Callaville	6.55	Speers Ferry	0.80
Washington	51.5	+ 2.4	Colfax	87	10	2 stations	17	29	2.63	+ 0.04	Cedar Lake	11.20	Pomeroy	0.15
West Virginia	55.4	+ 0.5	Wheeling	93	5	2 stations	18	[2] 18	2.45	− 0.50	Bluefield	4.81	Kanawha Falls	0.39
Wisconsin	50.5	+ 2.6	2 stations	90	[2] 4	2 stations	11	20	1.01	− 1.62	2 stations	2.13	Beloit	0.24
Wyoming	45.6	+ 3.0	Gillette	98	3	2 stations	0	[2] 29	0.84	− 0.29	Ervay	2.95	Pinebluff	T.

LATE REPORTS FOR SEPTEMBER, 1922.

Hawaii	74.8	0.0	Mahukona	96	25	Kula Sanitarium, Maui.	51	2	7.36	+ 1.70	Eke, Maui	30.50	Lahaina, Maui	0.11
Porto Rico	78.6	− 0.3	4 stations	97	[2] 7	4 stations	60	[2] 4	6.51	− 1.65	Mayaguez	23.42	Isabela	2.30

[1] For description of tables and charts, see REVIEW, July, 1922, pp. 384-385.

[2] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau Stations, October, 1922.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.									Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Direction.	Date.						
	Ft.	Ft.	Ft.	In.	In.	In.	°F	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
New England.							51.5	+0.8										75	2.69	−0.9										5.4		
Eastport	76	67	85	29.80	29.89	−0.11	45.6	−1.9	75	3	52	25	19	39	26	42	39	80	3.01	−0.8	15	8,516	w.	37	s.	24	6	5	20	7.3	0.7	0.0
Greenville, Me.	1,070	6	....	28.74	29.92	......	43.0	......	84	1	51	17	19	35	38	....	....	....	3.14	......	12	......	......	....	....	....	8	4	19	....	1.2	0.0
Portland, Me.	103	82	117	29.84	29.96	−.08	49.6	−0.3	83	5	57	24	19	42	30	44	38	71	2.13	−1.5	9	6,678	nw.	42	s.	23	12	8	11	5.2	0.0	0.0
Concord	288	70	79	29.65	29.97	−.08	49.0	+0.3	88	2	60	18	21	38	41	....	....	....	2.27	−1.0	6	4,317	nw.	37	w.	18	10	8	13	5.7	0.0	0.0
Burlington	404	11	48	29.51	29.95	−.09	46.9	0.0	81	2	56	20	19	38	28	....	....	....	1.98	−1.2	17	8,698	s.	42	s.	14	7	7	17	6.7	1.2	0.0
Northfield	876	12	60	29.02	29.98	−.07	45.0	+1.4	85	1	56	14	19	34	41	41	39	84	1.63	−0.8	10	6,186	s.	31	n.	29	6	11	14	6.6	1.0	0.0
Boston	125	115	188	29.83	29.97	−.08	55.1	+1.5	87	5	64	28	19	46	30	48	43	70	1.97	−1.9	5	7,778	w.	36	w.	18	15	6	10	4.7	0.0	0.0
Nantucket	12	14	90	29.95	29.96	−.09	55.9	+1.4	81	3	62	34	19	50	23	52	48	77	5.34	+2.0	7	12,197	sw.	48	sw.	25	11	12	8	5.1	0.0	0.0
Block Island	26	11	46	29.94	29.97	−.08	55.8	+0.9	77	3	62	33	19	50	20	51	48	78	2.94	−1.2	8	14,164	sw.	59	nw.	24	12	6	13	5.2	0.0	0.0
Providence	160	215	251	29.79	29.97	−.08	53.8	+1.6	87	5	63	28	19	45	28	48	43	70	2.66	−1.2	8	9,438	nw.	48	nw.	18	15	5	11	4.5	0.0	0.0
Hartford	159	122	140	29.80	29.98	−.08	54.4	+3.2	87	2	64	28	19	44	35	48	44	76	2.48	−1.4	6	5,643	nw.	39	sw.	23	16	5	10	4.7	0.0	0.0
New Haven	106	74	153	29.87	29.99	−.07	55.0	+1.2	88	5	64	29	21	46	29	49	44	70	3.18	−0.7	5	6,983	sw.	40	sw.	23	18	7	6	3.7	0.0	0.0
Middle Atlantic States.							58.2	+2.4										72	2.43	−0.8										4.1		
Albany	97	102	115	29.88	29.99	−.07	52.2	+0.1	88	5	62	25	19	42	34	46	42	76	1.56	−1.4	7	5,132	nw.	38	s.	23	16	8	7	4.0	T.	0.0
Binghamton	871	10	84	29.06	30.00	−.06	52.1	+2.9	87	6	63	23	21	41	36	....	....	....	1.95	−1.2	8	4,259	nw.	30	nw.	18	11	5	15	6.1	T.	0.0
New York	314	414	454	29.66	30.00	−.06	57.6	+1.3	87	5	65	34	27	50	24	51	45	69	1.17	−2.5	8	12,348	nw.	60	nw.	24	18	5	8	3.9	0.0	0.0
Harrisburg	374	94	104	29.63	30.03	−.05	57.7	+3.7	89	5	67	33	21	48	30	50	44	66	3.16	+0.2	6	4,324	w.	28	sw.	23	16	8	7	4.3	0.0	0.0
Philadelphia	117	123	190	29.89	30.02	−.05	60.6	+4.3	91	5	69	38	31	52	20	52	46	64	0.71	−2.4	6	7,246	sw.	29	sw.	11	16	5	10	4.1	0.0	0.0
Reading	325	81	98	29.66	30.01	......	58.0	......	89	5	68	30	21	48	32	50	45	68	1.18	−2.1	6	3,897	nw.	24	nw.	12	16	10	5	3.5	0.0	0.0
Scranton	805	111	119	29.15	30.02	−.05	54.3	+2.9	87	6	65	26	21	44	34	47	43	73	3.56	+0.6	7	5,191	sw.	27	sw.	18	11	11	9	5.2	T.	0.0
Atlantic City	52	37	172	29.96	30.01	−.06	59.2	+2.3	86	3	66	33	27	52	26	54	50	75	1.50	−1.8	6	12,017	nw.	48	s.	7	18	5	8	3.7	0.0	0.0
Cape May	18	13	49	30.03	30.05	−.02	60.1	+3.8	84	3	67	35	21	53	25	54	50	76	1.07	−2.2	10	6,319	sw.	36	s.	23	16	7	8	3.9	0.0	0.0
Sandy Hook	22	10	55	29.97	29.99	......	58.5	......	86	5	65	36	27	52	24	52	48	74	1.28	......	8	11,563	nw.	50	s.	23	17	7	7	3.6	0.0	0.0
Trenton	190	159	183	29.80	30.00	......	57.7	......	88	5	68	32	21	48	35	51	45	70	0.81	−2.6	5	7,952	sw.	39	w.	23	16	5	10	4.1	0.0	0.0
Baltimore	123	100	113	29.89	30.02	−.06	60.6	+2.4	91	5	70	37	31	52	28	53	48	68	5.58	+2.6	6	3,926	sw.	22	sw.	11	16	7	8	4.2	0.0	0.0
Washington	112	62	85	29.90	30.02	−.06	59.4	+2.0	87	5	70	33	21	49	32	52	47	72	1.41	−1.7	5	3,459	n.	28	n.	26	14	11	6	4.1	0.0	0.0
Lynchburg	681	153	188	29.30	30.04	−.05	60.6	+2.1	89	3	73	35	19	48	39	51	47	72	4.19	+0.8	8	4,399	w.	31	nw.	26	18	4	9	3.8	0.0	0.0
Norfolk	91	170	205	29.95	30.04	−.03	64.3	+3.0	87	4	72	43	25	57	30	57	54	76	2.75	−1.2	9	8,871	ne.	40	nw.	23	15	8	8	4.5	0.0	0.0
Richmond	144	11	52	29.89	30.04	−.04	60.8	+1.0	89	5	72	34	27	50	33	54	50	77	3.68	+0.1	8	5,022	ne.	34	sw.	11	18	5	8	3.4	0.0	0.0
Wytheville	2,304	49	55	27.69	30.06	−.03	55.6	+2.0	84	5	68	30	19	43	42	47	43	73	4.61	+1.5	7	3,501	nw.	24	sw.	25	20	5	6	3.2	0.0	0.0
South Atlantic States.							65.8	+1.6										77	5.40	+1.8										4.7		
Asheville	2,255	70	84	27.72	30.07	−.02	56.6	+1.3	81	30	69	32	19	45	41	48	44	74	3.36	+0.9	6	4,034	se.	26	n.	12	16	7	8	4.0	0.0	0.0
Charlotte	779	55	62	29.21	30.05	−.03	62.8	+1.1	87	5	73	43	27	53	33	54	48	68	5.32	+2.2	10	2,835	ne.	15	w.	7	17	6	8	3.8	0.0	0.0
Hatteras	11	12	11	30.01	30.02	−.04	67.0	+1.1	80	10	71	54	25	63	16	62	60	81	2.48	−3.5	9	9,685	n.	37	n.	18	16	5	10	4.6	0.0	0.0
Manteo	12	5	42	......	......	......	63.7	......	84	4	73	38	31	54	30	....	....	....	6.86	......	5	......	ne.	....	....	....	17	4	10	....	0.0	0.0
Raleigh	376	103	110	29.64	30.04	−.03	63.2	+2.7	88	4	73	42	27	54	31	55	50	72	3.74	+0.2	9	5,400	ne.	30	s.	9	15	7	9	4.2	0.0	0.0
Wilmington	78	81	91	29.95	30.04	−.02	66.1	+2.8	84	5	75	45	27	58	32	60	58	82	6.40	+2.7	10	5,102	ne.	23	se.	9	16	5	10	4.1	0.0	0.0
Charleston	48	11	92	29.96	30.01	−.05	68.7	+0.9	86	7	75	52	27	62	19	64	62	84	5.72	+1.8	7	7,784	ne.	32	ne.	13	10	10	11	5.3	0.0	0.0
Columbia, S. C.	351	41	57	29.66	30.04	−.03	65.2	+1.2	86	4	75	42	25	55	35	57	53	73	6.65	+3.8	10	4,221	ne.	25	ne.	13	18	3	10	4.1	0.0	0.0
Due West	711	10	55	29.29	30.06	......	62.6	......	86	4	73	40	24	52	31	....	....	....	3.14	......	9	5,683	ne.	26	nw.	7	17	6	8	4.3	0.0	0.0
Greenville, S. C.	1,039	113	122	28.94	30.03	......	62.4	......	84	4	72	42	25	53	32	54	49	69	4.77	......	7	5,548	ne.	30	e.	13	19	5	7	3.5	0.0	0.0
Augusta	180	62	77	29.82	30.01	−.06	66.5	+1.2	87	4	76	43	25	57	34	59	56	77	6.50	+4.2	9	3,399	e.	19	ne.	13	14	7	10	5.0	0.0	0.0
Savannah	65	150	194	29.93	30.00	−.05	69.0	+2.7	89	7	76	54	14	62	22	63	61	83	4.94	+1.4	8	7,957	ne.	32	ne.	13	8	7	16	6.3	0.0	0.0
Jacksonville	43	209	245	29.91	29.96	−.06	72.6	+1.5	88	7	78	56	11	67	20	68	67	88	8.84	+3.8	18	9,057	n.	35	n.	20	3	12	16	7.2	0.0	0.0
Florida Peninsula.							78.1	+ 1.2										82	11.50	+ 5.2										6.3		
Key West	22	10	64	29.87	29.89	− .05	80.1	+ 1.0	90	6	85	70	13	76	13	74	72	79	8.31	+ 2.9	12	7,496	se.	34	se.	14	10	10	11	5.3	0.0	0.0
Miami	25	71	79	29.88	29.91	......	78.0	+ 0.2	90	5	83	68	11	73	17	74	72	84	15.85	+ 5.3	26	5,348	se.	26	e.	14	3	7	21	7.9	0.0	0.0
Sand Key	23	39	72	29.87	29.90	− .04	79.0	......	87	6	82	68	31	76	13	74	72	78	9.05	......	12	10,485	s.	48	s.	15	10	11	10	5.4	0.0	0.0
Tampa	35	79	92	29.88	29.92	− .06	76.1	+ 2.3	90	17	83	60	12	70	18	70	69	85	10.33	+ 7.4	15	4,816	e.	25	se.	1	3	15	13	6.7	0.0	0.0
East Gulf States							66.9	+ 0.6										75	3.46	+ 0.7										5.0		
Atlanta	1,174	190	216	28.79	30.03	− .04	63.2	+ 0.2	83	4	72	41	24	54	24	56	52	73	3.48	+ 1.1	8	8,032	e.	28	nw.	23	13	6	12	5.0	0.0	0.0
Macon	370	78	87	29.62	30.02	− .04	66.2	+ 2.5	87	7	76	43	25	56	33	58	54	74	4.73	+ 2.6	9	4,407	ne.	20	nw.	23	12	8	11	5.3	0.0	0.0
Thomasville	273	49	58	29.67	29.97	− .07	69.7	+ 1.5	90	17	78	49	25	62	27	62	60	80	4.75	+ 1.3	13	3,414	ne.	18	ne.	14	7	5	19	6.9	0.0	0.0
Apalachicola	36	42	49	29.91	29.94	......	70.6	......	84	8	76	55	10	65	19	66	64	85	7.42	......	13	7,146	ne.	27	ne.	2	10	9	12	5.9	0.0	0.0
Pensacola	56	149	185	29.89	29.95	− .08	69.4	− 0.5	84	1	76	48	10	63	20	63	60	76	6.58	+ 2.5	11	9,946	ne.	42	se.	29	12	3	16	5.8	0.0	0.0
Anniston	741	9	57	29.25	30.04	− .03	64.2	+ 1.8	89	4	76	36	24	53	36	....	....	....	1.99	− 0.4	4	3,771	se.	16	se.	14	14	9	8	4.4	0.0	0.0
Birmingham	700	11	48	29.27	30.04	− .03	65.8	+ 1.4	88	1	77	40	24	55	35	55	50	67	1.81	− 0.5	3	4,411	e.	18	se.	31	13	8	10	4.6	0.0	0.0
Mobile	57	125	161	29.90	29.96	− .08	68.7	− 0.7	87	1	77	48	25	60	27	62	59	80	4.61	+ 1.4	10	7,089	n.	32	e.	3	12	8	11	5.1	0.0	0.0
Montgomery	223	100	112	29.76	30.01	− .05	66.6	0.0	87	1	76	45	25	58	28	59	55	73	3.26	+ 0.8	6	4,538	ne.	22	nw.	7	14	4	13	4.8	0.0	0.0
Corinth	469	6	....	......	......	......	64.0	......	92	3	79	35	19	49	45	....	....	....	0.98	......	5	......	ne.	....	....	....	12	15	4	....	0.0	0.0
Meridian	375	85	93	29.60	29.99	− .07	64.0	+ 1.0	86	1	75	39	25	53	33	57	53	75	2.30	− 0.4	6	3,672	ne.	22	nw.	7	14	8	9	4.6	0.0	0.0
Vicksburg	247	65	73	29.73	30.01	− .06	66.8	+ 0.1	89	1	77	40	19	56	33	57	53	69	1.33	− 1.5	6	4,210	ne.	23	ne.	2	18	4	9	3.9	0.0	0.0
New Orleans	53	76	84	29.89	29.94	− .09	71.6	+ 0.6	89	6	79	57	26	65	19	63	59	73	3.25	+ 0.3	8	5,398	ne.	24	e.	2	14	10	7	4.2	0.0	0.0
West Gulf States.							68.0	+ 1.3										68	2.86	+ 0.1										3.4		
Shreveport	249	77	93	29.73	30.00	− .05	67.0	+ 1.4	89	2	80	44	19	54	35	56	51	66	0.45	− 2.7	5	3,773	se.	26	nw.	8	22	6	3	2.8	0.0	0.0
Bentonville	1,303	11	44	......	......	......	60.4	+ 2.4	89	4	74	25	18	47	36	....	....	....	1.06	......	6	......	......	....	....	....	16	8	7	....	0.0	0.0
Fort Smith	457	79	94	29.52	30.00	− .05	64.2	+ 2.5	90	5	76	37	18	52	36	53	46	60	2.80	0.0	6	4,836	e.	26	nw.	22	15	9	7	4.1	0.0	0.0
Little Rock	357	136	144	29.63	30.00	− .06	65.2	+ 2.3	90	2	76	40	18	54	34	55	49	64	0.77	− 1.8	4	4,977	s.	30	nw.	7	16	8	7	3.1	0.0	0.0
Brownsville	57	4	26	29.85	29.92	......	73.7	......	91	7	82	54	20	65	27	66	63	78	0.74	......	5	5,327	se.	26	nw.	31	17	6	8	3.8	0.0	0.0
Corpus Christi	20	11	73	29.94	29.96	− .04	73.4	+ 0.8	90	10	82	57	19	65	32	65	62	75	5.88	+ 3.8	5	6,977	n.	46	n.	23	17	9	5	3.5	0.0	0.0
Dallas	512	109	117	29.45	30.00	......	67.4	......	89	5	79	42	24	56	36	....	....	....	2.87	......	7	4,476	se.	31	nw.	8	14	10	7	4.0	0.0	0.0
Fort Worth	670	106	114	29.27	29.98	− .05	67.6	+ 1.3	90	1	79	41	24	56	36	56	49	61	2.33	− 0.2	7	5,491	se.	32	nw.	8	16	10	5	3.6	0.0	0.0
Galveston	54	106	114	29.91	29.97	− .06	71.0	− 1.7	86	1	77	52	25	65	22	65	62	76	4.78	+ 0.6	10	7,445	n.	38	n.	7	22	5	4	2.9	0.0	0.0
Groesbeck	461	11	56	29.50	29.98	......	67.8	......	91	1	81	41	24	55	41	....	....	....	1.42	......	9	5,745	n.	32	nw.	8	21	5	5	2.9	0.0	0.0
Houston	138	111	121	29.82	29.96	......	71.2	+ 1.3	92	7	82	51	19	60	33	....	....	....	2.90	......	7	4,964	n.	31	e.	25	18	8	5	3.2	0.0	0.0
Palestine	510	64	72	29.46	29.99	− .04	67.6	+ 1.4	90	1	79	45	24	56	33	57	52	66	3.26	− 0.3	7	4,144	ne.	24	nw.	8	16	10	5	3.7	0.0	0.0
Port Arthur	34	58	66	29.91	29.95	......	69.0	......	89	7	80	45	19	59	29	66	58	77	3.16	......	6	5,611	n.	32	s.	31	20	5	6	3.0	0.0	0.0
San Antonio	701	119	132	29.24	29.96	− .05	71.4	+ 2.2	97	7	83	48	19	60	36	59	52	60	3.55	+ 2.1	5	5,325	n.	38	nw.	22	17	10	4	3.4	0.0	0.0
Taylor	582	55	63	29.40	30.01	− .01	69.0	+ 0.7	94	7	82	43	24	56	38	....	....	....	1.93	− 0.6	4	5,027	n.	26	n.	23	19	8	4	3.4	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau Stations, October, 1922*—Continued.

Districts and stations.	Elevation of instruments: Barometer above sea level.	Elevation of instruments: Thermometer above ground.	Elevation of instruments: Anemometer above ground.	Pressure: Station, reduced to mean of 24 hours.	Pressure: Sea level, reduced to mean of 24 hours.	Pressure: Departure from normal.	Temperature of the air: Mean max.+mean min.÷2.	Temperature of the air: Departure from normal.	Temperature of the air: Maximum.	Temperature of the air: Date.	Temperature of the air: Mean maximum.	Temperature of the air: Minimum.	Temperature of the air: Date.	Temperature of the air: Mean minimum.	Temperature of the air: Greatest daily range.	Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation: Total.	Precipitation: Departure from normal.	Precipitation: Days with 0.01 inch or more.	Wind: Total movement.	Wind: Prevailing direction.	Wind: Maximum velocity: Miles per hour.	Wind: Maximum velocity: Direction.	Wind: Maximum velocity: Date.	Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Ft.	Ft.	Ft.	In.	In.	In.	° F.	° F.	° F		° F	° F.		° F	° F.	° F	° F	N	In.	In.		Miles.								0-10	In.	In.
Ohio Valley and Tennessee.							59.6	+ 2.5										68	1.54	− 1.0										4.1		
Chattanooga	762	189	213	29.23	30.05	− .04	62.3	+ 0.4	88	5	73	40	25	51	34	53	46	64	1.72	− 1.1	5	4,265	ne.	25	sw.	11	16	11	4	3.9	0.0	0.0
Knoxville	996	102	111	29.00	30.05	− .04	60.8	+ 2.7	86	4	72	38	25	49	36	52	46	65	1.39	− 1.2	4	3,611	ne.	26	sw.	7	15	5	11	4.6	0.0	0.0
Memphis	399	76	97	29.63	30.06	− .01	65.3	+ 2.0	89	4	75	39	18	56	28	54	47	61	0.89	− 1.8	5	4,818	se.	30	nw.	23	17	5	9	4.0	0.0	0.0
Nashville	546	168	191	29.47	30.06	− .02	62.4	+ 1.4	87	2	74	37	19	50	35	52	46	63	0.75	− 1.7	5	5,662	ne.	32	nw.	7	16	6	9	4.1	0.0	0.0
Lexington	989	193	230	28.98	30.04	− .04	61.0	+ 4.5	87	4	70	38	13	52	27	...	...	...	1.25	− 1.0	7	9,107	sw.	37	sw.	10	21	0	10	3.4	0.0	0.0
Louisville	525	219	255	29.46	30.05	− .03	61.5	+ 2.2	89	4	72	38	19	51	32	52	46	65	2.24	− 0.4	7	6,935	s.	33	s.	25	20	4	7	3.4	0.0	0.0
Evansville	431	139	175	29.57	30.04	− .04	62.4	+ 4.4	91	4	72	39	13	52	29	52	46	63	2.12	− 1.0	8	6,920	sw.	30	n.	17	14	10	7	4.0	0.0	0.0
Indianapolis	822	194	230	29.15	30.03	− .04	59.1	+ 4.1	89	4	68	35	18	50	30	50	44	66	1.78	− 1.0	8	7,439	s.	32	nw.	23	18	4	9	4.1	0.0	0.0
Royal Center	736	11	55	29.22	30.02	...	56.2	...	89	4	68	30	18	45	35	...	...	...	4.83	...	7	6,349	s.	29	nw.	11	13	9	9	4.4	0.0	0.0
Terra Haute	575	96	129	29.40	30.02	...	59.4	...	90	4	70	34	18	48	32	50	44	67	2.22	...	8	5,981	s.	25	nw.	11	13	10	8	4.4	0.0	0.0
Cincinnati	628	11	51	29.37	30.04	− .04	57.9	+ 2.2	88	5	69	32	19	46	36	...	46	72	1.23	− 1.1	7	4,098	nw.	29	sw.	7	18	5	8	3.7	0.0	0.0
Columbus	824	179	222	29.16	30.03	− .05	57.4	+ 2.2	86	4	68	34	27	47	34	49	43	68	1.56	− 0.8	8	7,043	s.	37	nw.	23	13	8	10	4.7	0.0	0.0
Dayton	899	181	216	29.05	30.00	...	57.7	+ 3.6	87	2	68	34	19	48	32	49	44	68	1.10	− 1.3	8	6,450	sw.	31	w.	7	18	4	9	4.0	0.0	0.0
Elkins	1,947	59	67	28.01	30.08	− .02	53.2	+ 1.8	82	5	68	23	27	38	43	44	41	80	1.20	− 1.2	7	2,912	w.	24	nw.	23	13	10	8	4.7	0.0	0.0
Parkersburg	638	77	84	29.40	30.06	− .02	57.6	+ 3.0	88	5	70	30	27	46	37	49	46	78	2.73	+ 0.3	8	3,017	se.	24	s.	23	18	4	9	4.1	0.0	0.0
Pittsburgh	842	353	410	29.13	30.04	− .04	56.4	+ 0.7	86	5	66	34	21	47	31	49	43	68	1.62	− 0.7	8	7,055	sw.	36	sw	11	12	8	11	4.8	0.0	0.0
Lower Lake Region.							52.9	+ 0.8										72	2.06	− 0.9										5.4		
Buffalo	767	247	280	29.16	29.99	− .06	51.8	− 0.1	80	1	59	28	20	45	24	47	44	76	2.70	− 0.8	7	12,861	sw.	62	sw.	25	11	8	12	5.5	T.	0.0
Canton	448	10	61	29.46	29.94	...	46.3	− 0.9	80	2	56	21	20	37	40	...	...	...	2.61	− 0.7	13	7,845	sw.	47	sw.	17	8	8	15	6.4	0.7	0.0
Oswego	335	76	91	29.61	29.98	− .06	50.4	− 0.8	80	6	59	23	19	42	33	46	42	76	2.72	− 0.6	12	7,930	s.	40	nw.	18	10	6	15	5.9	0.0	0.0
Rochester	523	86	102	29.43	30.01	− .04	51.5	0.0	83	1	60	28	29	43	28	45	40	70	2.30	− 0.6	11	5,895	sw.	36	w.	18	10	6	15	5.9	0.1	0.0
Syracuse	597	97	113	29.35	29.99	− .07	50.8	− 0.2	84	6	59	22	19	42	34	...	...	...	2.25	− 1.0	13	8,122	s.	46	nw.	18	7	8	16	6.7	T.	0.0
Erie	714	130	166	29.23	30.00	− .05	54.6	+ 1.2	83	5	62	32	21	47	30	48	43	68	2.01	− 1.8	9	10,547	s.	38	sw.	25	12	6	13	5.2	T.	0.0
Cleveland	762	190	201	29.19	30.02	− .04	55.4	+ 1.8	83	5	62	35	19	48	27	48	43	69	1.58	− 1.2	9	9,383	s.	41	nw.	25	13	7	11	5.2	0.0	0.0
Sandusky	629	62	103	29.33	30.02	− .04	56.2	+ 2.3	88	5	64	32	19	48	30	...	...	...	1.21	− 1.2	8	8,976	sw.	36	sw.	25	10	11	10	5.2	0.0	0.0
Toledo	628	208	243	29.34	30.02	− .03	55.2	+ 1.8	86	5	64	32	20	46	33	48	44	73	1.98	− 0.3	6	10,236	sw.	49	sw.	23	16	7	8	4.3	0.0	0.0
Fort Wayne	856	113	124	29.10	30.03	...	55.5	+ 1.8	88	2	65	32	19	46	39	48	44	73	2.62	...	8	6,324	sw.	30	nw.	11	13	9	9	4.9	0.0	0.0
Detroit	730	218	258	29.23	30.02	− .03	54.6	+ 2.1	87	5	63	31	20	47	30	48	43	73	1.22	− 1.2	8	7,827	sw.	38	w.	11	17	6	8	4.5	T.	0.0
Upper Lake Region.							49.6	+ 1.7										77	1.70	− 1.1										5.7		
Alpena	609	13	92	29.32	29.99	− .04	47.4	+ 0.3	86	4	55	26	24	40	31	43	40	80	2.08	− 1.4	13	8,684	nw.	40	nw.	25	7	12	12	6.4	T.	0.0
Escanaba	612	54	60	29.32	29.99	− .02	46.4	+ 1.3	86	4	54	26	20	39	27	42	39	80	0.71	− 2.4	7	7,684	n.	37	s.	13	9	11	11	5.5	T.	0.0
Grand Haven	632	51	89	29.31	29.99	− .04	51.6	+ 1.4	76	4	59	28	20	44	31	47	43	76	2.21	− 0.3	7	8,670	s	52	w.	16	8	11	12	5.7	0.0	0.0
Grand Rapids	707	70	87	29.24	30.01	− .03	53.0	+ 2.9	85	5	62	28	20	44	29	46	42	73	2.87	+ 0.3	9	4,257	w.	25	w.	16	7	12	12	5.7	T.	0.0
Houghton	684	62	99	29.24	29.97	− .03	44.6	− 0.5	78	2	52	25	20	37	27	...	...	...	0.62	− 2.6	9	7,787	e.	42	w.	24	10	2	19	6.8	1.4	0.0
Lansing	878	11	62	29.05	30.01	...	51.8	+ 3.1	87	5	63	25	20	41	35	44	42	81	2.48	+ 0.2	9	3,827	sw.	23	nw.	23	8	12	11	5.6	T.	0.0
Ludington	637	60	66	29.29	29.99	...	50.2	...	78	1	57	26	20	43	29	46	43	79	2.58	...	9	8,243	s.	39	w.	16	11	13	7	4.7	T.	0.0
Marquette	734	77	111	29.20	30.01	.00	46.6	+ 0.9	89	4	55	26	18	39	35	41	37	78	1.74	− 1.4	10	7,765	nw.	37	nw.	24	5	5	21	7.2	1.1	0.0
Port Huron	638	70	120	29.30	30.00	− .04	51.6	+ 1.1	86	5	60	30	13	43	29	45	44	82	1.29	− 1.4	7	7,776	sw.	34	nw.	17	9	12	10	5.3	T.	0.0
Saginaw	641	69	77	29.30	30.01	...	51.0	...	86	5	60	26	20	42	35	45	42	82	1.70	...	9	6,073	ne.	27	s.	13	11	9	11	5.3	T.	0.0
Sault Sainte Marie	614	11	52	29.29	30.00	− .01	43.9	+ 0.5	82	4	52	20	20	36	29	40	36	81	2.06	− 1.2	14	6,077	nw.	46	nw.	25	7	8	16	6.6	5.1	0.0
Chicago	823	140	310	29.12	30.00	− .04	57.6	+ 2.5	87	5	65	36	18	51	27	50	44	64	3.40	+ 0.8	8	8,566	nw.	33	s.	13	15	9	7	4.1	0.0	0.0
Green Bay	617	109	144	29.31	29.98	− .04	50.0	+ 2.9	84	4	58	25	18	42	29	44	40	75	0.47	− 1.9	6	8,816	s.	36	s.	13	10	8	13	6.0	T.	0.0
Milwaukee	681	125	139	29.26	29.99	− .04	54.4	+ 4.2	87	5	62	31	18	47	26	48	43	72	1.62	− 0.8	7	7,855	sw.	32	s.	13	11	11	9	5.2	0.0	0.0
Duluth	1,133	11	47	28.74	29.97	− .03	46.0	+ 1.9	85	2	54	21	18	38	32	40	37	81	0.56	− 2.2	7	9,690	ne.	51	nw.	24	11	7	13	5.4	T.	0.0
North Dakota.							46.6	+ 3.3										66	0.59	− 0.7										5.2		
Moorhead	940	50	58	28.93	29.95	− .05	47.8	+ 3.3	93	3	60	17	18	36	43	39	32	64	0.16	− 1.9	4	6,229	n.	36	nw.	24	11	6	14	5.5	0.3	0.0
Bismarck	1,674	8	57	28.20	30.01	+ .02	47.6	+ 2.7	91	1	61	20	17	34	43	39	32	65	0.63	− 0.4	4	5,943	nw.	36	nw.	24	13	10	8	4.4	2.5	0.0
Devils Lake	1,482	11	44	28.37	29.96	− .03	44.7	+ 4.2	88	1	56	19	17	33	44	37	31	70	0.52	− 0.7	6	7,388	nw.	42	nw.	24	13	4	14	5.3	0.3	0.0
Ellendale	1,457	10	56	28.40	29.97	...	47.4	...	93	3	62	18	12	33	53	...	...	...	0.45	...	4	10,112	nw.	48	nw.	24	10	8	13	5.3	1.2	0.0
Grand Forks	835	12	89	...	...	...	46.4	...	95	3	60	14	18	32	54	...	...	...	0.20	...	4	...	nw.	56	nw.	24	18	2	11	...	0.8	0.0
Williston	1,878	41	48	27.96	29.96	− .02	46.5	+ 3.1	86	3	58	20	16	34	44	39	32	66	1.06	+ 0.3	5	5,121	sw.	29	w.	24	11	9	11	5.4	8.2	0.5
Upper Mississippi Valley.							57.3	+ 4.2										68	1.57	− 0.9										4.2		
Minneapolis	918	102	208	28.95	29.93	...	53.6	...	80	4	62	30	12	45	28	...	...	...	1.21	− 1.4	5	8,577	nw.	37	nw.	24	10	10	11	5.3	0.4	0.0
St. Paul	837	236	261	29.05	29.96	− .05	52.3	+ 3.7	87	4	62	27	18	43	32	...	...	...	1.08	− 1.3	7	8,842	sw.	40	w.	24	11	12	8	4.8	T.	0.0
La Crosse	714	11	48	29.21	29.98	− .04	53.9	+ 3.6	87	4	66	25	18	42	36	...	...	...	1.24	− 1.2	7	3,266	se.	18	s.	4	13	7	11	5.0	0.0	0.0
Madison	974	70	78	28.96	30.01	− .02	53.9	+ 5.1	86	5	63	30	18	45	29	46	41	70	0.65	− 1.8	4	6,883	sw.	33	s.	13	12	8	11	5.0	0.0	0.0
Wausau	1,247	4	...	28.66	30.01	...	48.4	...	84	5	58	24	20	38	33	...	...	...	0.54	...	5	...	se.	...	...	...	14	5	12	4.7	T.	0.0
Charles City	1,015	10	49	28.91	30.00	− .02	53.7	+ 5.5	86	4	66	24	18	42	38	45	41	74	2.38	+ 0.4	6	3,951	se.	25	se.	13	14	10	7	3.9	T.	0.0
Davenport	606	71	79	29.34	30.00	− .04	58.6	+ 6.0	89	3	70	31	18	47	36	48	42	65	0.42	− 2.0	3	4,472	sw.	27	nw.	16	20	3	8	3.5	0.0	0.0
Des Moines	861	84	97	29.08	29.98	− .05	57.4	+ 4.9	88	5	69	28	18	46	38	48	42	65	3.41	+ 0.7	8	4,852	sw.	32	sw.	13	19	6	6	3.5	0.0	0.0
Dubuque	698	81	96	29.26	30.02	− .02	55.4	+ 3.5	87	5	66	32	18	44	35	47	42	70	0.72	− 2.0	6	4,309	s.	24	s.	13	15	7	9	4.4	0.0	0.0
Keokuk	614	64	78	29.34	30.02	− .03	59.4	+ 4.9	90	3	70	32	17	48	36	49	43	63	0.77	− 1.7	5	4,419	sw.	33	nw.	16	18	6	7	3.7	0.0	0.0
Cairo	358	87	93	29.64	30.02	− .05	62.0	+ 1.6	89	3	72	38	18	52	29	53	48	70	2.54	− 0.1	8	4,765	s.	30	n.	17	14	7	10	4.7	0.0	0.0
Peoria	609	11	45	29.36	30.03	− .02	58.0	+ 6.0	92	3	70	29	18	46	36	49	45	76	2.02	− 0.6	6	3,565	s.	20	sw.	24	23	1	7	2.9	0.0	0.0
Springfield, Ill	644	10	91	29.32	30.01	− .04	59.2	+ 3.4	89	4	70	34	17	48	32	50	45	69	1.95	− 0.6	8	5,470	s.	25	nw.	16	14	7	10	4.6	0.0	0.0
Hannibal	534	74	109	29.45	30.02	− .03	59.1	+ 3.2	90	3	71	33	17	48	36	...	...	...	1.83	+ 0.2	5	5,255	sw.	31	nw.	16	21	3	7	3.3	0.0	0.0
St. Louis	567	265	303	29.40	30.01	− .05	62.2	+ 3.8	90	3	72	38	18	53	31	52	44	59	1.74	− 0.7	7	8,148	s.	37	n.	16	17	5	9	4.2	0.0	0.0
Missouri Valley.							57.1	+4.0										61	1.25	− 0.6										3.4		
Columbia, Mo	781	11	84	29.19	30.02	−.03	59.4	+4.6	89	4	71	30	18	47	35	...	...	...	1.50	−0.9	6	4,612	se.	26	nw.	16	21	2	8	3.3	0.0	0.0
Kansas City	963	161	181	28.98	30.01	−.03	60.6	+4.8	87	4	71	34	17	50	33	51	44	61	2.31	+0.1	5	6,735	s.	40	n.	16	21	4	6	2.8	0.0	0.0
St. Joseph	967	11	49	28.96	30.00	...	59.4	...	90	6	71	30	17	48	36	49	43	66	2.72	...	6	5,139	s.	37	nw.	16	23	3	5	2.7	0.0	0.0
Springfield, Mo	1,324	98	104	28.63	30.03	−.02	61.0	+3.7	86	3	71	32	18	50	30	50	43	62	1.60	−1.2	6	6,529	se.	39	w.	22	18	8	5	3.0	0.0	0.0
Iola	984	11	50	28.97	30.01	−.03	60.4	+3.5	89	3	74	28	18	47	44	...	...	...	1.30	−1.0	6	3,800	s.	27	n.	16	17	8	6	3.7	0.0	0.0
Topeka	987	92	107	...	...	...	59.6	+3.3	90	6	72	32	17	48	38	...	...	...	1.69	−0.2	6	6,610	s.	37	n.	16	22	1	8	2.8	0.0	0.0
Drexel	1,299	10	54	28.58	29.97	...	57.8	...	90	27	71	20	17	44	45	...	...	...	1.32	...	5	7,439	s.	32	s.	28	18	10	3	3.2	T.	0.0
Lincoln	1,189	11	84	28.72	29.98	−.05	58.9	+5.6	89	27	72	22	17	45	47	47	38	56	1.42	−0.4	4	7,126	s.	36	nw.	6	20	7	4	3.0	0.0	0.0
Omaha	1,105	115	122	28.81	29.99	−.04	59.6	+5.4	90	27	71	27	17	48	42	48	41	60	1.45	−0.9	5	4,988	nw.	37	nw.	16	19	9	3	3.2	T.	0.0
Valentine	2,598	47	54	27.28	30.01	.00	51.2	+2.7	96	4	68	18	17	35	51	40	30	55	0.61	−0.7	4	6,157	w.	36	s.	12	15	12	4	3.5	T.	0.0
Sioux City	1,135	94	164	28.76	29.98	−.04	56.1	+5.0	88	4	68	23	17	44	43	46	38	59	1.11	−0.7	5	8,463	s.	42	nw.	16	15	11	5	3.8	0.0	0.0
Huron	1,306	59	74	28.59	30.00	−.01	51.4	+3.7	93	4	66	21	17	37	46	42	34	63	0.84	−0.5	4	6,436	nw.	34	nw.	16	16	7	8	3.7	T.	0.0
Pierre	1,572	70	75	28.31	29.99	−.02	52.2	+2.4	97	3	68	21	17	37	49	41	32	66	0.44	−0.4	4	5,538	nw.	33	sw.	3	15	7	9	4.0	T.	0.0
Yankton	1,233	49	57	28.65	29.97	−.04	55.0	+3.9	91	4	68	24	17	42	44	...	...	...	0.73	−0.8	5	4,945	nw.	32	nw.	16	13	11	7	4.5	0.0	0.0

TABLE 1.—*Climatological data for Weather Bureau Stations, October 1, 1922*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.									Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow, sleet, and ice on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
Northern Slope.							48.6	+3.9										53	0.56	−0.4										4.1		
Billings	3,140	5	....	....	....	....	51.0	....	95	3	69	20	16	33	57	....	....	....	0.94	....	5	....	nw.	....	....	....	14	7	10	....	0.0	0.0
Havre	2,505	11	44	27.33	29.98	.00	47.9	+3.4	81	2	63	14	30	33	47	40	32	62	0.09	−0.4	3	4,971	sw.	30	sw.	23	16	5	10	4.4	0.0	0.0
Helena	4,110	87	112	25.81	30.00	−.03	49.8	+5.8	80	1	62	21	30	38	37	38	26	45	0.06	−0.8	2	5,922	sw.	38	nw.	15	13	9	9	4.7	T.	0.0
Kalispell	2,973	48	56	26.94	30.00	−.01	47.6	+5.1	73	2	59	24	30	36	35	40	34	64	1.05	−0.1	8	3,366	nw.	24	ne.	15	16	6	9	4.3	0.0	0.0
Miles City	2,371	48	55	27.47	30.03	+.03	50.4	+3.9	91	3	64	22	17	36	42	40	30	54	0.52	−0.3	4	4,108	s.	30	n.	4	13	7	11	4.5	T.	0.0
Rapid City	3,259	50	58	26.61	30.04	+.03	51.0	+4.4	91	3	66	16	17	36	44	39	27	44	0.60	−0.5	3	6,165	w.	37	s.	12	13	13	5	3.9	4.0	T.
Cheyenne	6,088	84	101	24.04	30.02	+.01	47.5	+2.2	82	3	61	15	17	34	43	35	24	46	0.23	−0.5	4	8,254	w.	40	w.	24	19	6	6	3.4	2.5	T.
Lander	5,372	60	68	24.69	30.06	+.02	46.2	+4.1	80	3	60	10	31	32	44	37	28	57	1.97	+0.9	5	3,136	sw.	40	w.	4	17	9	5	4.0	16.0	8.4
Sheridan	3,790	10	47	26.12	30.05	....	47.3	....	89	3	64	12	31	30	53	36	26	55	1.35	....	9	3,443	nw.	26	n.	15	11	14	6	4.5	8.1	5.0
Yellowstone Park	6,200	11	48	23.92	30.05	+.03	43.7	+2.2	76	2	57	20	30	31	42	34	23	49	0.34	−0.8	2	6,323	sw.	35	sw.	4	12	12	7	4.4	3.0	T.
North Platte	2,821	11	51	27.10	30.04	+.02	53.6	+3.9	89	4	71	16	17	36	53	40	30	54	0.14	−1.0	1	4,396	w.	29	n.	16	19	5	7	3.1	0.0	0.0
Middle Slope.							58.3	+2.7										54	1.50	0.0										2.9		
Denver	5,292	106	113	24.76	30.02	+0.1	52.8	+1.6	86	3	66	24	17	39	40	39	24	41	0.30	−0.7	4	5,109	s.	29	ne.	16	18	8	5	3.1	0.5	0.0
Pueblo	4,685	80	86	25.31	29.99	.00	54.2	+1.9	90	4	72	21	31	37	48	39	26	40	0.19	−0.5	2	3,901	nw.	27	ne.	6	21	9	1	2.6	0.0	0.0
Concordia	1,392	50	58	28.52	30.00	−.03	59.8	+4.4	90	5	73	26	17	46	45	48	39	57	1.14	−0.9	6	6,056	s.	30	s.	13	19	9	3	3.1	0.0	0.0
Dodge City	2,509	11	51	27.42	30.02	.00	59.0	+4.3	89	26	74	31	23	44	50	46	37	56	0.45	−1.0	3	6,827	s.	31	ne.	16	22	5	4	2.4	0.0	0.0
Wichita	1,358	139	158	28.55	29.98	−.05	60.9	+2.1	87	6	72	37	17	49	36	50	42	59	2.59	+0.3	5	8,732	s.	50	sw.	13	20	7	4	2.7	0.0	0.0
Altus	1,410	5	....	....	....	....	66.2	....	95	6	81	37	18	51	43	....	....	....	0.77	....	4	....	se.	....	....	....	20	8	3	....	0.0	0.0
Broken Arrow	765	11	52	29.20	30.02	....	62.6	....	90	3	76	32	18	50	40	....	....	....	2.06	....	8	7,805	s.	40	n.	16	19	7	5	3.1	0.0	0.0
Muskogee	652	4	....	....	....	....	64.9	....	95	3	80	29	18	50	44	....	....	....	1.14	....	6	....	....	....	....	....	18	8	5	....	0.0	0.0
Oklahoma City	1,214	10	47	28.74	30.01	−.02	63.3	+2.0	90	6	75	39	18	52	38	53	49	70	4.30	+2.5	7	7,367	s.	33	n.	7	21	6	4	3.1	0.0	0.0
Southern Slope.							63.4	+1.0										55	1.02	−0.9										3.4		
Abilene	1,738	10	52	28.20	30.00	−.01	64.4	+0.2	91	6	76	38	24	52	47	53	46	64	2.43	+0.1	11	5,292	s.	32	s.	13	13	8	10	4.5	0.0	0.0
Amarillo	3,676	10	49	26.28	29.99	−.01	60.4	+4.3	89	6	74	34	31	46	42	47	39	55	0.23	−1.5	3	7,425	s.	39	n.	6	24	5	2	3.1	0.0	0.0
Del Rio	944	64	71	28.99	29.96	−.02	69.3	−0.6	97	10	80	47	24	58	42	....	....	....	1.30	−0.7	7	5,379	e.	35	nw.	7	19	4	8	3.4	0.0	0.0
Roswell	3,566	75	85	26.37	29.96	.00	59.6	−0.1	91	2	76	30	31	44	49	45	32	45	0.10	−1.4	4	5,346	s.	38	sw.	13	19	9	3	2.7	0.0	0.0
Southern Plateau.							60.9	+0.9										35	0.12	−0.5										1.5		
El Paso	3,762	110	133	26.18	29.91	−.01	64.0	+1.6	90	11	76	37	31	52	35	50	38	47	0.35	−0.6	4	6,500	e.	45	nw.	28	21	9	1	2.3	0.0	0.0
Santa Fe	7,013	38	53	23.27	29.94	−.02	51.4	+1.4	77	4	64	23	29	39	32	38	26	45	0.24	−0.8	3	4,126	e.	24	nw.	19	25	4	2	1.9	1.8	0.0
Flagstaff	6,908	10	59	23.37	29.94	+.02	46.2	+1.5	75	2	63	5	30	29	47	34	....	5	1.07	....	3	5,497	w.	29	sw.	27	25	4	2	....	11.0	2.0
Phoenix	1,108	11	81	28.70	29.84	−.04	71.6	+1.4	100	9	88	38	31	55	40	55	43	42	T.	−0.4	0	3,469	e.	22	w.	28	27	3	1	1.2	0.0	0.0
Yuma	141	9	54	29.70	29.84	−.03	73.7	+0.4	101	3	90	42	31	58	40	57	45	44	0.00	−0.2	0	2,767	w.	19	w.	28	29	2	0	0.9	0.0	0.0
Independence	3,957	9	41	25.96	29.97	+.02	58.5	−0.8	82	1	72	32	30	45	38	43	24	29	T.	−0.3	0	4,931	nw.	35	se.	2	26	5	0	1.3	0.0	0.0
Middle Plateau.							52.2	+1.3										45	0.28	−0.5										3.0		
Reno	4,532	74	81	25.47	29.98	−.01	51.5	+1.8	77	7	67	20	30	36	45	40	30	50	0.09	−0.3	3	4,384	w.	35	sw.	2	17	12	2	2.9	0.0	0.0
Tonopah	6,090	12	20	24.08	29.96	....	52.6	....	75	1	62	19	29	43	28	39	24	35	0.01	−0.8	1	7,323	se.	37	nw.	28	21	9	1	2.1	0.0	0.0
Winnemucca	4,344	18	56	25.62	30.02	−.03	49.0	+0.4	82	9	67	11	30	31	51	38	27	51	0.31	−0.2	2	4,442	sw	37	sw.	2	17	6	8	3.7	0.0	0.0
Modena	5,479	10	43	24.62	29.96	.00	49.5	−0.6	78	2	66	21	31	32	48	37	22	39	0.37	−0.4	1	7,092	w.	44	s.	3	21	8	2	2.5	0.8	0.0
Salt Lake City	4,360	163	203	25.63	29.98	−.03	55.8	+3.3	83	10	66	34	31	46	30	44	34	48	0.66	−0.7	3	5,061	nw.	29	s.	2	16	7	8	3.9	T.	0.0
Grand Junction	4,602	60	68	25.40	29.98	−.01	55.1	+1.8	86	2	69	28	31	41	38	42	31	47	0.25	−0.7	4	3,738	se.	32	sw.	12	18	9	4	2.7	T.	0.0
Northern Plateau.							53.6	+4.0										56	0.71	−0.5										4.6		
Baker	3,471	48	53	26.45	30.03	−.05	49.6	+4.1	80	10	64	20	30	35	44	41	32	56	0.40	−0.5	5	4,780	se.	30	sw.	2	13	6	12	5.3	0.0	0.0
Boise	2,739	78	86	27.16	30.01	−.05	56.2	+5.9	86	10	70	26	30	43	38	45	34	49	0.52	−0.8	3	3,710	se.	39	w.	3	18	6	7	3.8	0.0	0.0
Lewiston	757	40	48	29.23	30.01	−.06	55.1	+3.3	82	1	68	28	30	42	38	....	....	....	0.86	−0.3	6	1,442	se.	22	w.	19	12	6	13	5.3	0.0	0.0
Pocatello	4,477	60	68	25.48	29.99	−.05	52.3	+4.3	83	10	65	25	30	40	40	41	28	46	0.76	−0.2	4	6,205	se.	40	sw.	4	17	6	8	4.0	T.	0.0
Spokane	1,929	101	110	27.96	30.01	−.05	51.6	+3.3	77	10	63	26	29	40	34	45	39	66	0.83	−0.7	8	3,196	sw.	30	sw.	3	13	8	10	5.0	0.0	0.0
Walla Walla	991	57	65	28.92	30.00	−.07	56.5	+2.8	75	15	66	35	30	47	31	49	42	62	0.89	−0.6	6	2,825	s.	20	e.	2	16	4	11	4.3	0.0	0.0
North Pacific Coast Region.							53.8	+1.8										86	3.94	+0.1										7.3		
North Head	211	11	56	29.78	30.00	−.05	54.1	+1.2	72	22	58	42	29	51	18	52	51	91	5.72	+1.8	16	7,939	n.	58	s.	24	10	9	12	5.7	0.0	0.0
Port Angeles	29	8	53	30.01	30.03	....	49.8	....	74	10	56	34	29	44	30	....	....	....	1.67	−0.9	12	3,122	s.	24	w.	27	7	3	21	7.2	0.0	0.0
Seattle	125	215	250	29.91	30.04	−.01	53.5	+2.7	73	6	58	34	29	48	26	50	48	84	2.37	−0.3	12	4,787	s.	31	s.	24	4	5	22	8.0	0.0	0.0
Tacoma	213	113	120	29.81	30.04	.00	52.4	+1.8	72	7	58	32	29	47	29	....	....	....	3.84	+0.4	13	3,086	n.	20	sw.	4	2	9	20	7.8	0.0	0.0
Tatoosh Island	86	9	57	29.90	30.00	−.01	52.4	+2.5	64	6	55	43	31	50	14	51	50	92	5.76	−2.2	13	9,376	e.	56	s.	24	2	7	22	8.4	0.0	0.0
Yakima	1,071	5	....	....	....	....	52.8	....	80	8	67	26	30	39	45	....	....	....	0.85	....	10	....	....	....	....	....	15	5	11	....	0.0	0.0
Medford	1,425	4	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Portland, Oreg	153	68	106	29.86	30.02	−.04	55.4	+1.2	78	8	62	39	30	49	27	52	50	84	4.70	+1.0	13	3,031	nw.	21	sw.	4	4	5	22	7.7	0.0	0.0
Roseburg	510	9	57	29.48	30.03	−.05	55.2	+1.3	74	7	64	38	30	47	29	52	48	79	3.50	+0.9	15	1,755	n.	18	s.	25	5	16	10	6.2	0.0	0.0
Middle Pacific Coast Region.							58.8	−0.6										71	2.51	+1.0										5.1		
Eureka	62	73	89	29.98	30.04	−.02	54.8	+1.7	74	22	60	40	29	49	24	52	49	84	3.38	+0.7	11	3,415	se.	30	sw.	3	8	7	16	6.4	0.0	0.0
Point Reyes	490	7	18	29.45	29.96	....	55.3	+0.6	76	21	59	47	24	51	23	....	....	....	1.77	....	10	14,388	nw.	56	nw.	28	6	10	15	6.5	0.0	0.0
Red Bluff	332	50	56	29.62	29.98	−.05	60.8	−3.5	84	22	71	40	30	50	32	54	47	66	3.95	+2.4	7	3,576	se.	28	nw.	29	14	9	8	4.1	0.0	0.0
Sacramento	69	106	117	29.90	29.97	−.02	61.9	−1.0	85	1	73	42	28	51	35	53	45	59	0.72	−0.3	7	4,718	s.	27	nw.	29	18	7	6	3.3	0.0	0.0
San Francisco	155	208	243	29.82	29.99	−.02	60.6	+0.1	81	21	67	49	25	54	25	54	50	76	2.95	+1.7	9	5,258	w.	26	se.	10	8	15	8	5.4	0.0	0.0
San Jose	141	12	110	29.85	30.00	....	59.2	−1.1	85	22	71	35	30	47	41	....	....	....	1.55	+0.6	9	3,815	nw.	25	ne.	29	12	10	9	4.6	0.0	0.0
South Pacific Coast Region.							63.8	+0.5										66	0.33	−0.5										2.5		
Fresno	327	89	98	29.61	29.97	+.01	64.2	−0.5	92	1	77	41	29	51	35	53	45	57	0.52	−0.2	2	4,555	nw.	26	nw.	27	24	4	3	1.8	0.0	0.0
Los Angeles	338	159	191	29.60	29.96	+.01	65.4	+0.1	90	1	75	50	30	56	37	55	49	66	0.24	−0.5	1	3,800	sw.	24	nw.	28	22	8	1	2.3	0.0	0.0
San Diego	87	62	70	29.85	29.94	−.01	64.0	+0.3	88	23	71	48	30	57	30	57	53	74	0.09	−0.4	2	4,428	nw.	30	w.	28	18	11	2	3.0	0.0	0.0
San Luis Obispo	201	32	40	29.77	29.99	.00	61.4	+2.2	91	23	74	36	30	48	45	52	46	69	0.47	−0.9	3	2,923	n.	17	w.	4	17	13	1	2.9	0.0	0.0
West Indies.																																
San Juan, P. R	82	9	54	29.85	29.93	....	79.0	....	90	3	85	70	7	73	16	....	....	....	3.28	−2.8	17	5,807	s.	29	e.	19	9	20	2	4.4	0.0	0.0
Panama Canal.																																
Balboa Heights	118	7	97	....	29.85	....	79.0	−0.2	89	29	74	84	20	74	15	74	73	86	9.03	−1.2	....	5,164	s.	36	s.	15	0	13	18	7.5	0.0	0.0
Colon	36	5	71	....	29.85	....	80.8	....	92	14	87	72	16	74	20	75	74	85	13.87	−1.0	....	4,820	se.	25	se.	27	2	10	19	7.6	0.0	0.0
Alaska.																																
Juneau	80	11	54	....	....	....	43.8	....	55	1	49	31	1	39	19	41	40	90	6.49	....	21	4,487	s.	28	se.	28	4	2	25	8.4	0.0	0.0

TABLE 2.—*Data furnished by the Canadian Meteorological Service, October, 1922.*

Stations.	Altitude above mean sea level, Jan. 1, 1919.	Pressure. Station reduced to mean of 24 hours.	Pressure. Sea level reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature of the air. Mean max.+mean min.÷2.	Temperature of the air. Departure from normal.	Temperature of the air. Mean maximum.	Temperature of the air. Mean minimum.	Temperature of the air. Highest.	Temperature of the air. Lowest.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Total snowfall.
	Feet.	*In.*	*In.*	*In.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	*In.*	*In.*	*In.*
St. Johns, N. F	125												
Sydney, C. B. I	48	29.79	29.84	−.12	47.6	+1.1	55.0	40.1	76	28	4.90	+0.21	T.
Halifax, N. S	88	29.76	29.87	−.13	47.8	+0.6	54.9	40.6	76	24	3.87	−1.68	3.5
Yarmouth, N. S	65	29.82	29.89	−.13	47.7	+0.1	53.9	41.5	68	29	3.38	−1.32	1.9
Charlottetown, P. E. I	38	29.77	29.81	−.15	45.7	−0.8	52.4	39.0	82	28	1.76	−3.14	T.
Chatham, N. B	28	29.74					53.4		79		1.99	−1.87	0.4
Father Point, Que	20	29.82	29.84	−.11	37.6	−2.2	45.0	30.3	64	18	4.02	+1.12	1.2
Quebec, Que	296	29.59	29.92	−.08	42.2	−0.2	49.1	35.4	74	19	3.05	−0.10	2.1
Montreal, Que	187	29.72	29.93	−.08	44.8	0.0	51.9	37.6	76	20	3.39	+0.26	3.5
Stonecliffe, Ont	489												
Ottawa, Ont	236	29.70	29.96	−.05	45.5	+1.7	55.0	36.0	86	18	3.06	+0.51	3.0
Kingston, Ont	285	29.66	29.97	−.06	48.0	+1.0	55.2	40.8	72	21	2.51	−0.22	1.0
Toronto, Ont	379	29.57	29.98	−.06	49.8	+3.2	58.5	41.1	83	25	0.96	−1.40	T.
Cochrane, Ont	930												
White River, Ont	1,244	28.63	29.97	−.01	34.8	−2.3	45.7	24.0	80	−2	1.69	−0.66	1.2
Port Stanley, Ont	592	29.39	30.03	−.02	50.8	+3.0	60.1	41.6	74	25	1.50	−1.48	
Southampton, Ont	656	29.26			47.4	+1.3	54.9	39.9	75	24	2.08	−1.09	1.1
Parry Sound, Ont	688	29.27	29.97	−.04	44.3	+0.4	53.1	35.5	77	17	2.83	−1.09	3.6
Port Arthur, Ont	644	29.27	29.98	.00	40.9	+1.0	48.3	33.5	78	14	0.71	−1.85	T.
Winnipeg, Man	760	29.13	29.97	−.01	43.5	+4.4	53.5	33.6	86	18	0.51	−1.19	1.8
Minnedosa, Man	1,690	28.13	29.97	.00	40.9	+3.1	50.4	31.5	81	15	0.52	−0.68	0.8
Le Pas, Man	860				36.2		45.4	27.1	74	10	0.30		0.2
Qu'Appelle, Sask	2,115	27.65	29.91	−.06	42.3	+2.9	52.4	32.3	72	18	1.38	+0.28	6.2
Medicine Hat, Alb	2,144	27.61	29.88	−.09	48.7	+3.9	62.2	35.2	75	16	0.04	−0.54	
Moose Jaw, Sask	1,759				44.2		56.3	32.1	76	20	0.73		3.5
Swift Current, Sask	2,392	27.35	29.99	+.02	44.6	+2.5	58.7	30.5	75	14	0.24	−0.64	0.0
Calgary, Alb	3,428												
Banff, Alb	4,521	25.38	29.97	+.02	42.1	+2.9	54.6	29.7	69	20	1.03	+0.01	1.4
Edmonton, Alb	2,150	27.61	29.90	−.03	42.5	+1.4	53.7	31.4	69	11	0.84	+0.14	4.0
Prince Albert, Sask	1,450	28.40	29.99	+.02	39.5	+2.4	47.4	31.6	69	20	1.08	+0.25	0.8
Battleford, Sask	1,592	28.18	29.93	−.04	42.5	+2.9	53.5	31.5	78	20	1.13	+0.68	0.0
Kamloops, B. C	1,262	28.74	30.04	+.08	48.1	+1.1	56.6	39.7	67	27	1.25	+0.64	0.0
Victoria, B. C	230	29.76	30.02	+.01	51.7	+2.5	56.9	46.5	67	39	3.10	+0.73	0.0
Barkerville, B. C	4,180	25.64	29.96	+.02	39.9	+0.2	49.0	30.9	58	16	2.66	−0.04	14.9
Hamilton, Ber	151	29.88	30.04	+.02	73.3	+0.3	79.6	67.1	84	57	5.81	−0.90	

LATE REPORTS FOR AUGUST AND SEPTEMBER, 1922.

Calgary, Alb. August	3,428	26.44	29.94	+.03	63.3	+3.9	79.9	46.9	94	38	1.42	−0.72	0.0
Calgary, Alb. September	3,428	26.38	29.91	−.01	55.8	+6.0	71.9	39.7	88	29	1.55	+0.19	0.0
Kamloops, B. C. (September)	1,262	28.69	29.97	.00	61.6	+4.2	73.4	49.8	84	38	0.66	−0.19	0.0
Barkerville, B. C. (September)	4,180	25.63	29.92	−.06	46.4	−0.3	55.5	37.3	66	29	7.14	+4.23	9.7
Hamilton, Ber (September)	151	29.93	30.09	+.02	78.4	+1.0	84.3	72.5	88	69	6.90	+0.39	0.0

SEISMOLOGICAL REPORTS FOR OCTOBER, 1922.

W. J. HUMPHREYS, Professor in Charge.

[Weather Bureau, Washington, December 3, 1922.]

TABLE 1.—*Noninstrumental earthquake reports, October, 1922.*

Day.	Approximate time, Greenwich civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
1922.	*H. m.*		° ′	° ′			*Sec.*			
		CALIFORNIA.								
Oct. 18	5 30	Hollister	36 45	121 20	Slight.	2	3-4			Press report.
		OREGON.								
16	4 20	Hermiston	46 00	119 20	3	3	3,3,1	Rattling	Felt by several	C. L. Upham.
		WYOMING.								
26	1 20	Casper	43 00	106 20	3	1	Few.	None		Z. Q. Miller.
		Do	43 00	106 20	3-4	1	3	Rumbling	Felt by many	G. S. McKenzie.

TABLE 2.—*Instrumental seismological reports, October, 1922.*

Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.

[For significance of symbols and description of stations, see REVIEW for January, 1922.]

Date.	Character.	Phase.	Time.	Period T.	Amplitude.		Distance.	Remarks.
					A_E	A_N		
ALASKA.	*U. S. C. & G. S. Magnetic Observatory, Sitka.*							
1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Oct. 6		e_E	5 33 37	5				e phases may not be seismic.
		e_N	5 32 25					
		L_E	5 35 44	10				
		L_N	5 34 51					
		M_N	5 35 07	12		*100		
		F	5 39 ..					
24		*O*	21 20 54				4,750	
		P_E	21 29 05					
		S	21 35 34					
		$SR1_N$	21 38 59					
		L_E	21 41 54	36				
		M_E	21 44 52	25	*800			
		M_N	21 39 39	12		*500		
		F_E	22 08 ..					
		F_N	22 00 ..					
CALIFORNIA.	*Theosophical University, Point Loma.*							
1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Oct. 2					100	200		Tremors during preceding 24 hours.
3					50	50		
18					50	50		
COLORADO.	*Regis College, Denver.*							
1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Oct. 7		L_N	15 15 ..					Possibly not seismic. Very faint and small; no record on EW.
		F_N	15 19 ..					
11		P_N	11 59 ..					Very faint and indistinct; more probably seismic; possibly Peru quake.
		L	12 25 ..	25-30		*600		
25		L	22 23 ..					Extremely small, but certainly seismic; reported from Casper, Wyo.
		F	22 23 30					
DISTRICT OF COLUMBIA.	*U. S. Weather Bureau, Washington.*							
1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Oct. 6		iP	5 38 27				5,800	
		iS	5 45 53					L not visible.
		F	6 10 *ca*					
11		P	14 59 22				6,000	
		S	15 07 00					
		L	15 17 ..					
		L	15 22 ..	24				
		F	16 *ca*					
15		e	0 13 15					
		eL	0 50 ..					
		L	0 57 ..	20				
		F	1 25 *ca*					
24		P	21 34 43					
		S	21 44 47				8,900	
		L	22 01 20					
		F	22 50 *ca*					
HAWAII.	*U. S. C. & G. S. Magnetic Observatory, Honolulu.*							
1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Oct. 5		e_E	5 48 ..					Nothing definite.
		F_E	6 09 ..					
11		*O*	14 50 01				9,900	M_N occurs during SR2; L not apparent; waves very irregular.
		S	15 13 52					
		$SR1_E$	15 20 40					
		$SR1_N$	15 20 10					
		$eSR2_N$	15 26 20					
		L_E	15 32 30					
		M_E	15 34 54		*2,100			
		M_N	15 26 40			*3,200		
		F_E	15 47 ..					
		F_N	15 52 ..					
24		*O*	21 20 56				5,200	E not operating.
		iP_N	21 29 37					
		$iPR1_N$	21 31 29	9		38		
		iS_N	21 36 30	10		60		
		L_N	21 43 00	31		350		
		M_N	21 43 04	31				
		F_N	23 12 ..					
27		e_E	14 57 ..	22				N record very slight; E trace drifting off sheet.
		e_N	14 44 ..	10				
		F_N	15 04 ..					
ILLINOIS.	*U. S. Weather Bureau, Chicago.*							
1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Oct. 6		P	5 38 10				5,700	
		S	5 45 33					
		L?	5 51 30	15				
		F	6 20 *ca*					Lost in micros.
7		i	16 21 55					No phases; micros.
		F	16 30 *ca*					
11		P	14 59 49				5,900	
		S	15 07 18					
		L?	15 16 04	30				
		M_N	15 26 ..			*10,000		
		F	18 *ca*					Lost in micros.
14		e	23 11 40					
		F	23 23 *ca*					Micros.
15		P?	0 06 30					
		S?	0 15 25					
		eL	0 38 ..	35				
		L	0 46 ..	22				
		L	0 53 ..	18				
		F	2 20 *ca*					
16		e	16 46 ..					
		L	16 58 50	18				
		F	17 25 *ca*					
24		iP	21 34 27				7,900	
		PR1	21 37 30					
		PR2	21 39 30					
		iS	21 43 39					
		SR1	21 48 47					
		L	21 57 50	25*ca*				
		L	22 10 ..	15				
		F	24 *ca*					Lost in micros.
30		e	2 05 48					
		F	2 15 *ca*					Do.
30		e	2 58 05					
		F	3 10 *ca*					Do.

* Trace amplitude.

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TABLE 2.—*Instrumental seismological reports, October, 1922*—Continued.

MISSOURI. *St. Louis University, St. Louis.*

1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Oct. 11		iP	14 59 35				6,000	
		iS	15 07 24					
		eL	15 14 ..	18	*2,000			
		M	15 22 30	30		*3,000		
		F	15 41 ..					
24		iP	21 33 30				7,900	
		iS	21 42 48					
		eL	21 57 24	24		*1,000		
		F	22 17 ..					

NEW YORK. *Fordham University, Neu York.*

1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Oct. 5			5 53? ..					Faint quake; clock contact out of order.
24		e_N	21 33 28					Micros.
		e_E	21 43 08					
		i_N	21 43 36					
		e_E	21 43 36					
		L_E	21 56 ca.					
26			17 24 ..					Irregular waves of small amplitude.

CANAL ZONE. *Panama Canal, Balboa Heights.*

1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Oct. 11		P	14 55 24				3,200ca	Direction SE.
		S_E	15 00 12					
		S_N	15 00 20					
		L	15 03 56					
		M	15 01 08		*4,000	*7,500		
		F_E	15 22 00					
		F_N	15 30 00					
17								Very slight tremors from 3:33 to 3:38; distance and di: rection unknown-probably local.
19								Very slight tremor from 11:28 to 11:31; distance and direction unknown; probably local.
24		P	11 07 58				300ca.	Direction probably SW.
		S	11 08 30					
		M_E	11 08 43		*2,000			
		M_N	11 08 45			*3,000		
		F_E	11 13 20					
		F_N	11 14 00					
25		P_E	0 17 50				300ca.	Direction probably SW.
		P_N	0 17 56					
		S_E	0 18 22					
		S_N	0 18 28					
		M_E	0 18 32		*1,000			
		M_N	0 18 41			*1,000		
		F_E	0 21 00					
		F_N	0 22 00					
29		P	0 09 20				275ca.	Direction probably SW.
		S_E	0 09 48					
		S_N	0 09 50					
		L	0 10 10					
		M_E	0 09 50		*8,500			
		M_N	0 09 52			*8,000		
		F_E	0 16 00					
		F_N	0 17 00					

VERMONT. *U. S. Weather Bureau, Northfield.*

1922.			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*
Oct. 6		e	5 50 30				
		F	6 02 ca.				
11		P	14 50 58				6,700
		S	15 08 10				
		eL	15 18 10				
		L	15 23 ..	35			
		F	15 45 ca.				
24		P	21 33 45				8,300
		S	21 43 20				
		eL	21 59 ..				
		F	22 25 ..				

*Trace amplitude.

PORTO RICO. *U. S. C. & G. S. Magnetic Observatory, Vieques.*

1922			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Oct. 5		i_E	23 22 13	2	50			Local shock felt in Porto Rico.
		i_N	23 22 17			200		
		i_N	23 22 22					
		iM_E	23 22 17	2	640			
		M_N	23 22 25	4		680		
		C_E	23 23 05					
		C_N	23 23 43					
		F	23 28 ..					
11		O	14 49 51				3,620	Trace very irregular.
		P_E	14 56 47					
		$PR1_N$	14 57 51					
		S_E	15 02 13					
		S_N	15 02 06					
		$SR1_E$	15 04 46					
		$SR1_N$	15 04 51					
		$L1_N$	15 06 50					
		$L2_N$	15 08 58					
		M_E	14 55 00	14	*400			
		M_N	15 11 20	20		*500		
		F_E	15 26 ..					
		F_N	15 20 ..					

CANADA. *Dominion Observatory, Ottawa.*

1922			*H. m. s.*	*Sec.*	*μ*	*μ*	*Km.*	
Oct. 6		*O*	5 28 11				5,240	
		P	5 36 55					
		S	5 43 50					
		eL	5 49 ..					
		L	5 53 ..	9				
		F						Lost in micros.
7		e	16 26 49					Subscript M refers to Milne-Shaw N. S. comp.
		iM	16 26 55					
		eL	16 30 ..	7				
		F						Lost in micros.
11		*O*	14 49 40				6,880	
		P	15 00 01					
		PR1?	15 02 44					
		S	15 08 24					
		$SR1_M$?	(15 13 15)					
		SR2	15 15 20					
		eL	15 19 30	40				
		L	15 22 30	35				
		L	15 26 ..	24				
		L	15 34 30	17				
		F	16 25 ..					
14		$e?_E$	23 11 ..					
		eL_E	23 17 ..					
		F	23 25 ca.					
15		e	0 07 18					
		$e?_E$	0 12 ..					
		e_E	0 16 12					
		eL_E	0 31 ..					
		L_E	0 35 36	44				
		L_E	0 40 ..	31				
		L_E	0 44 ..	23				
		L_E	0 48 ..	20				
		L_E	0 51 ..	18				
		F	1 45 ..					
16		$e?_E$	16 44 30					
		eL_E	16 52 ..					
		L	16 57 ..	20				
		L	17 01 ..	18				
		F	17 20 ca.					
17		e?	7 32 ..					
		eL	7 37 ..					
		L_E	7 44 ..	28				
		L_E	7 50 30	22				
		L_E	8 01 ..	14				
		F	8 15 ca.					
24		*O*	21 22 03				8,050	Strasbourg wireless reports *O* 21:22:07, distance 8,720 km., Kamchatka.
		P	21 33 26					
		PR1	21 36 36					
		S	21 42 49					
		L	21 57 ..					
		L	22 01 ..	19				
		L	22 12 ..	15				
		F	23 ca.					
27		eL_E	15 15 ..					
		L_E	15 21 ..	21				
		L_E	15 26 ..	17				
		F						Lost in heavy micros.
30		e_E	2 08 37					Small irregular wavelets
		e_E	2 11 00					
		F						Micros.
30		e_E	3 00 24					Small irregular wavelets.
		F	3 09 ca.					

*Trace amplitude.

TABLE 2.—*Instrumental seismological reports, October, 1922*—Con.

CANADA. *Dominion Meteorological Service, Toronto.*

1922.			H m. s.	Sec.	μ	μ	Km.	
Oct. 6	....	L.....	0 46 12	....	....	....	....	May not be seismic.
		M.....	0 48 00	....	*200	....	....	
		F.....	0 52 00	....	....	....	....	
6	....	L.....	5 53 00	....	....	....	....	Gradual thickening.
		M?....	5 54 36	....	*200	....	....	
		F.....	5 56 30	....	....	....	....	
7	....	e?.....	16 19 00	....	....	....	....	Micros going on.
		L?....	16 20 00	....	*200	....	....	
		L?....	16 29 00	....	....	....	....	
17	....	L.....	7 56 36	....	*100	....	....	Instrument dismounted from 9th to 16th.
		F.....	7 57 54	....	....	....	....	
24	....	P.....	?21 34 18	....	....	....	....	Marking at 21*h*. 31*m*. 30*s*. doubtful as to being seismic; P not well defined.
		S.....	21 43 36	....	....	....	7970?	
		e.....	?21 48 24	....	....	....	....	
		L.....	21 55 24	....	....	....	....	
		eL....	22 02 48	....	....	....	....	
		M.....	22 20 48	....	*400	....	....	
		F.....	?23 47 12	....	....	....	....	
27	....	eL....	15 32 12	....	....	....	....	
		M.....	15 38 48	....	*200	....	....	
		F.....	....	....	....	....	....	
30	....	L.....	?1 56 30	....	....	....	....	Micros going on.
		L.....	?2 00 30	....	*100	....	....	
		L.....	?2 04 30	....	....	....	....	
30	....	e.....	2 58 30	....	....	....	....	Do.
		e.....	3 05 18	....	*50	....	....	
30	....	e.....	?13 12 42	....	....	....	....	Slow waves of disturbance.
		L.....	13 21 12	....	*100	....	....	
		L.....	13 38 24	....	....	....	....	

CANADA. *Dominion Meteorological Service, Victoria.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
Oct. 6	....	e.....	5 33 53	....	....	....	....	
		IL.....	5 36 11	....	*100	....	....	
		F.....	5 45 00	....	....	....	....	
7	....	L.....	16 12 08	....	*50	....	....	Minute marking.
		F.....	16 13 45	....	....	....	....	
11	....	P.....	15 01 33	....	....	....	....	
		L.....	15 10 24	....	....	....	....	
		M.....	15 12 37	....	*1,750	....	....	
		F.....	17 47 43	....	....	....	....	
15	....	P or S.	4 25 37	....	....	....	....	
		L.....	4 34 32	....	....	....	....	
		M.....	4 38 30	....	*400	....	....	
		F.....	5 32 04	....	....	....	....	
16	....	M.....	16 55 05	....	*200	....	....	
17	....	L.....	7 38 30	....	....	....	....	Time estimated; watch stopped—mainspring broken.
		M.....	7 45 00	....	*250	....	....	
		F.....	7 53 00	....	....	....	....	
24	....	L.....	21 30 41	....	....	....	....	
		M.....	21 51 50	....	*1,000	....	....	
		F.....	23 29 42	....	....	....	....	
27	....	L.....	15 12 00	....	....	....	....	
		M.....	15 19 52	....	*250	....	....	
		F.....	15 36 06	....	....	....	....	
30	....	L.....	1 50 27	....	....	....	....	
		M.....	1 51 56	....	*300	....	....	
		F.....	1 58 19	....	....	....	....	
30	....	L.....	2 43 27	....	....	....	....	
		M.....	2 44 06	....	*200	....	....	
		F.....	2 46 55	....	....	....	....	
30	....	L.....	13 44 59	....	....	....	....	
		M.....	13 51 25	....	*250	....	....	
		F.....	13 58 27	....	....	....	....	

* Trace amplitude.

Reports for October, 1922, have not been received from the following stations:

ALABAMA. *Spring Hill College*, Mobile.

ARIZONA. *U. S. C. & G. S. Magnetic Observatory*, Tucson.

DISTRICT OF COLUMBIA. *Georgetown University*, Washington.

MARYLAND. *U. S. C. & G. S. Magnetic Observatory*, Cheltenham.

MASSACHUSETTS. *Harvard University*, Cambridge.

NEW YORK. *Cornell University*, Ithaca.

TABLE 3.—*Late reports (instrumental).*

DISTRICT OF COLUMBIA. *Georgetown University, Washington.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
Sept. 1	....	eP_N...	19 34 41	....	....	....	....	P_E does not show.
		eS_E...	19 45 35	....	....	....	....	
		S_N....	19 45 35	....	....	....	....	
		eL_E?..	19 57 18	27	....	....	....	No distinct M on EW.
		eL_N?..	19 57 18	27	....	....	....	
		L_E....	20 12 ..	33	....	....	....	
		L_N....	20 13 ..	38	....	....	....	
		M_N....	20 28 18	....	....	*1700	....	
		F.....	21 15 ..	....	....	....	....	
			VERTICAL.					
		eP_Z...	19 34 52	....	....	....	....	Heavy micros.
		S_Z....	19 44 38	....	....	....	....	
		L_Z....	20 22 ..	22	....	....	....	
		F.....	21 15 ..	....	....	....	....	
3	....	eP_E?..	3 51 19	....	....	....	....	Difficult.
		S_E?....	3 54 06	....	....	....	....	
		S_N?...	3 54 06	....	....	....	....	
		eL_N?..	3 57 06	....	....	....	....	
		F.....	....	....	....	....	....	Not apparent.
4	....	e_E.....	17 12 ..	....	....	....	....	
		e_N.....	17 12 16	....	....	....	....	
		i_N.....	17 14 14	....	....	....	....	
		i_E.....	17 18 40	....	....	....	....	
		i_N.....	17 18 40	....	....	....	....	
		F.....	18 35 ..	....	....	....	....	
14	....	e_N.....	19 48 ..	....	....	....	....	Heavy micros.
		S_N?...	19 57 21	....	....	....	....	
		eL_N?..	20 15 24	....	....	....	....	
		L_E....	20 29 27	32	....	....	....	
		L_N....	20 30 27	32	....	....	....	
		F.....	21 45 ..	....	....	....	....	
29	....	e......	21 40 48	....	....	....	....	Very heavy micros.
		eL_E?..	21 57 00	....	....	....	....	
		F.....	22 10 ..	....	....	....	....	
30	....	e_E.....	23 47 11	....	....	....	....	Heavy micros.
		e_N.....	23 46 08	....	....	....	....	
		F.....	23 58 ..	....	....	....	....	

MISSOURI. *St. Louis University, St. Louis.*

1922.			H. m. s.	Sec.	μ	μ	Km.	
July 2	....	iP.....	13 44 48	....	....	....	5400	No earthquakes recorded during August.
		iS.....	13 51 48	....	....	....	....	
		eL....	13 55 54	....	....	....	....	
		M.....	14 04 ..	18	*2000	....	....	
		F.....	14 42 ..	....	....	....	....	
Sept. 1	....	iP.....	19 31 ..	....	....	....	....	
		iS.....	19 43 06	....	....	....	11,500	
		eL....	20 06 ..	....	....	....	....	
		M.....	20 16 ..	24	*2,000	....	....	
		F.....	20 36 ..	....	....	....	....	
4	....	i......	17 19 06	....	....	....	....	
		i......	17 21 12	....	....	....	....	
		F.....	17 35 ..	....	....	....	....	

* Trace amplitude.

Reports for October, 1922, have not been received from the following stations:

ALABAMA. Spring Hill College, Mobile.

ARIZONA. U. S. C. & G. S., Magnetic Observatory, Tucson.

DISTRICT OF COLUMBIA. Georgetown University, Washington.

MARYLAND. U. S. C. & G. S., Magnetic Observatory, Cheltenham.

MASSACHUSETTS. Harvard University, Cambridge.

NEW YORK. Cornell University, Ithaca.

Chart I. Tracks of Centers of Anticyclones, October, 1922. (Inset) Departure of Monthly Mean Pressure from Normal.

(Plotted by Wilfred P. Day.)

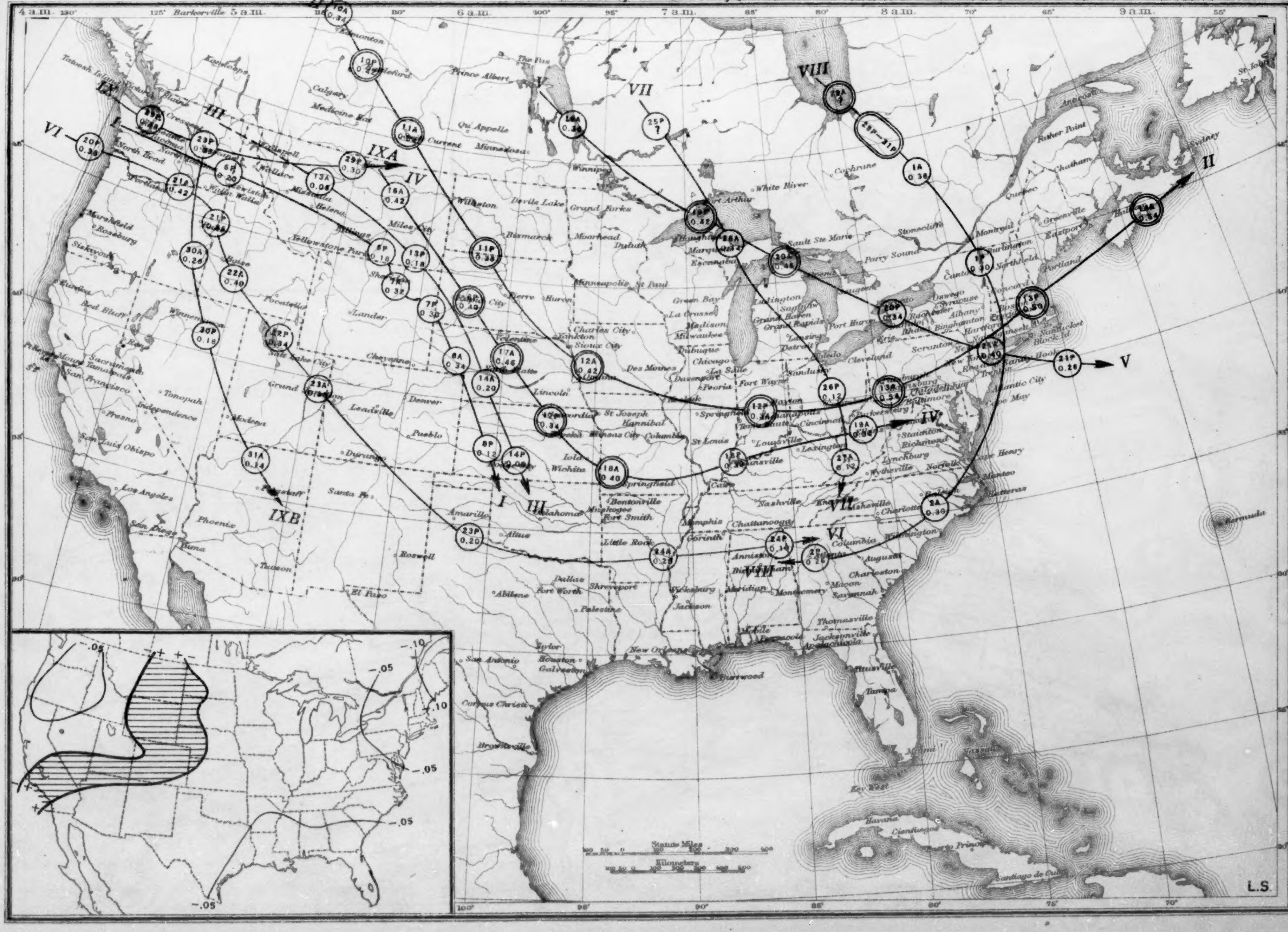


Chart II. Tracks of Centers of Cyclones, October, 1922. (Inset) Change in Mean Pressure from Preceding Month.

(Plotted by Wilfred P. Day.)

Chart III. Departure (°F.) of the Mean Temperature from the Normal, October, 1922.

Chart III. Departure (°F.) of the Mean Temperature from the Normal, October, 1922.

Shaded portions show excess (+).
Unshaded portions show deficiency (−).
Lines show amount of excess or deficiency.

Chart IV. Total Precipitation, Inches, October, 1922. (Inset) Departure of Precipitation from Normal.

Chart V. Percentage of Clear Sky between Sunrise and Sunset, October, 1922.

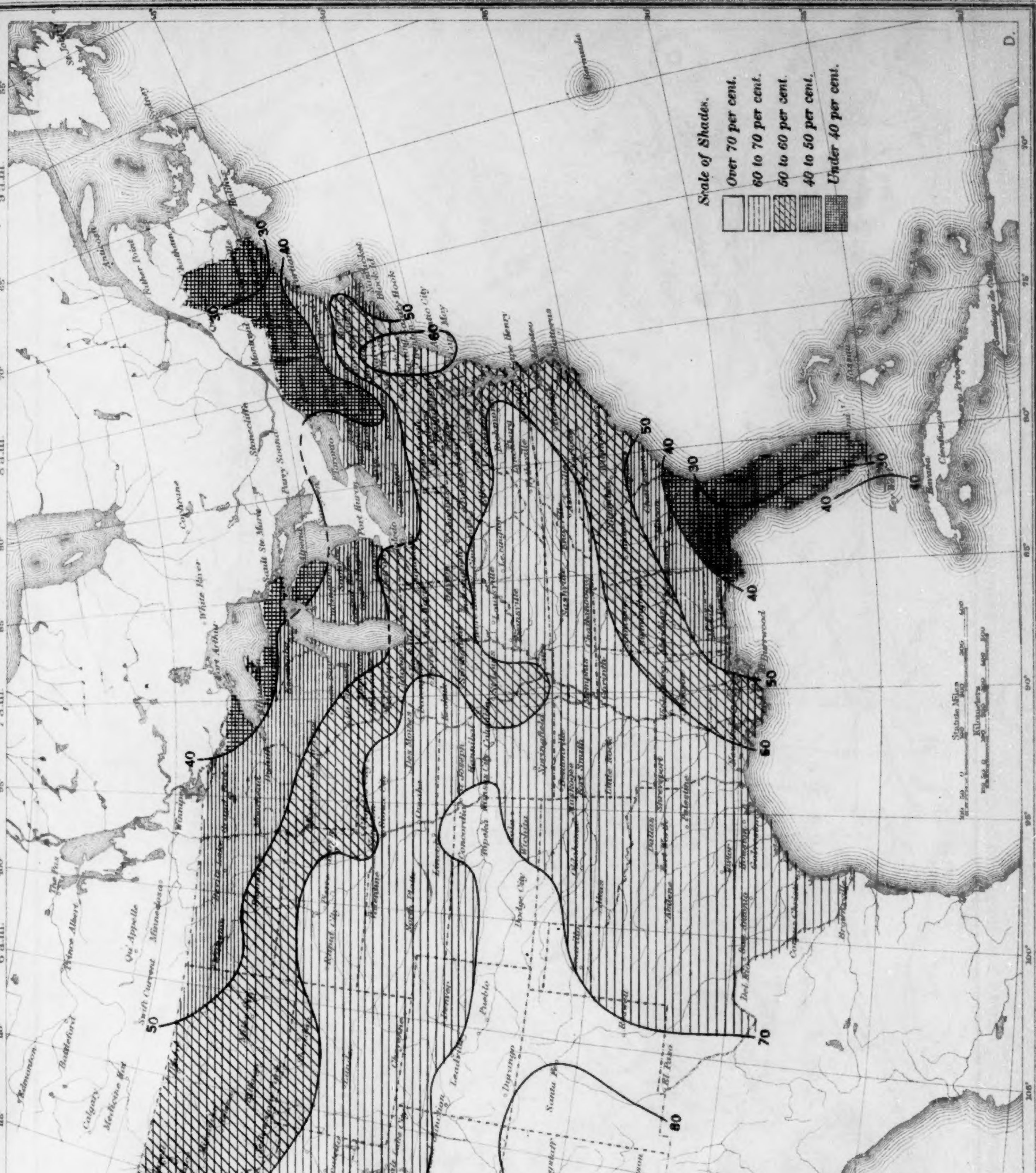


Chart VI. Isobars at Sea-level and Isotherms at Surface; Prevailing Winds, October, 1922.

Chart VIII. Weather Map of North Atlantic Ocean, October 16, 1922.

Chart VIII. Weather Map of North Atlantic Ocean, October 16, 1922.
(Plotted by F. A. Young.)

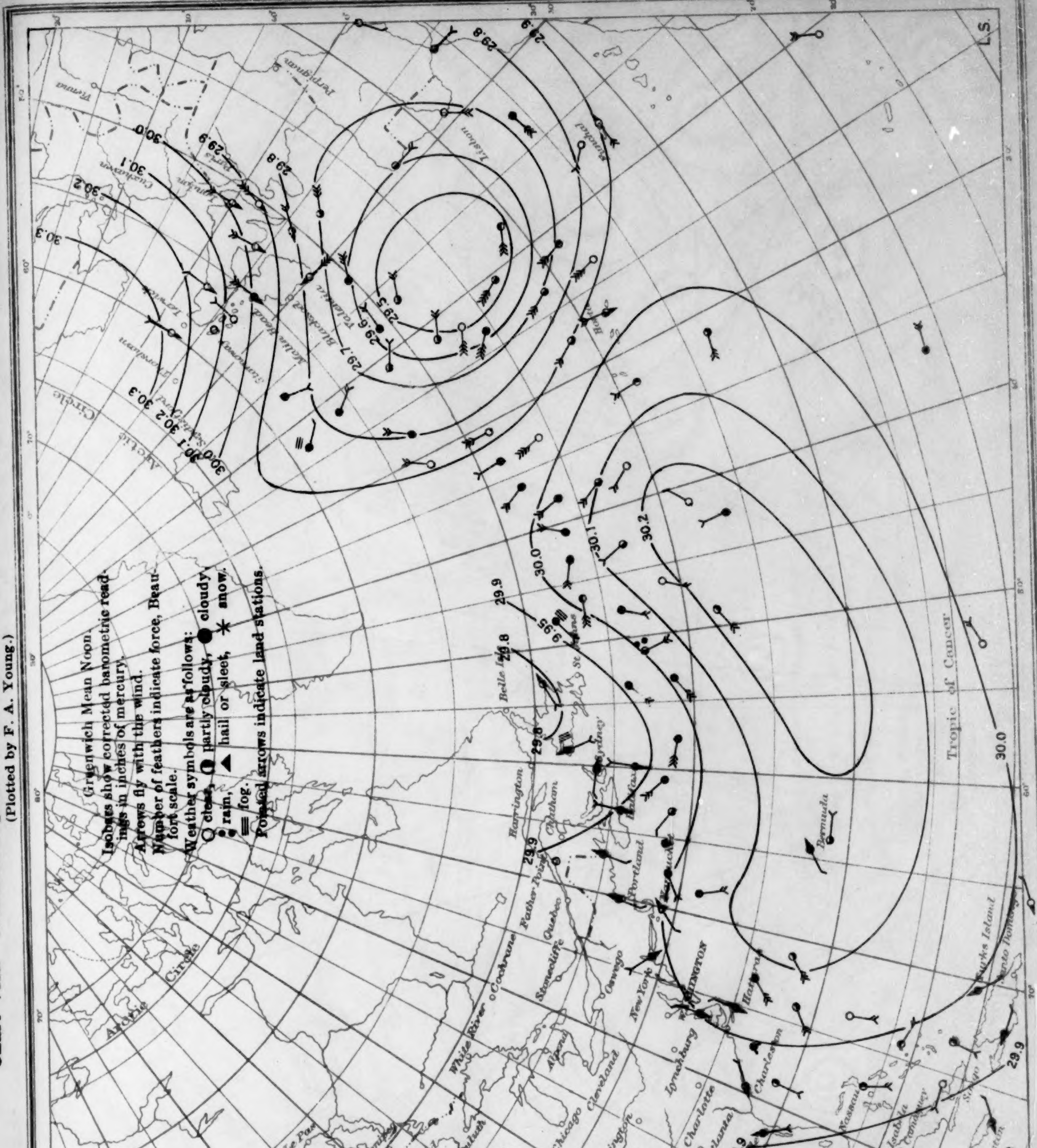


Chart IX. Weather Map of North Atlantic Ocean, October 17, 1922.
(Plotted by F. A. Young.)

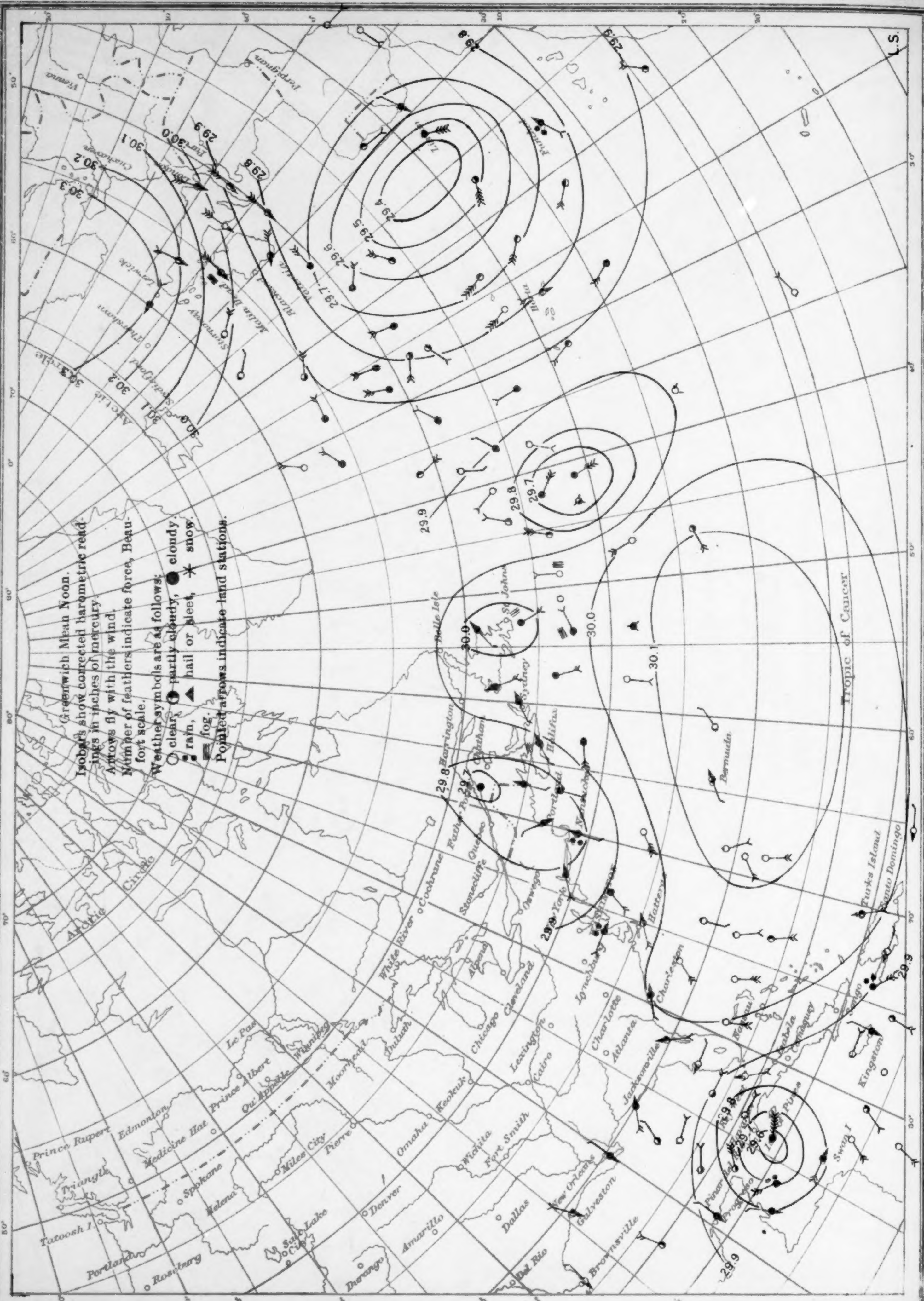


Chart X. Weather Map of North Atlantic Ocean, October 18, 1922.

Chart X. Weather Map of North Atlantic Ocean, October 18, 1922.

(Plotted by F. A. Young.)

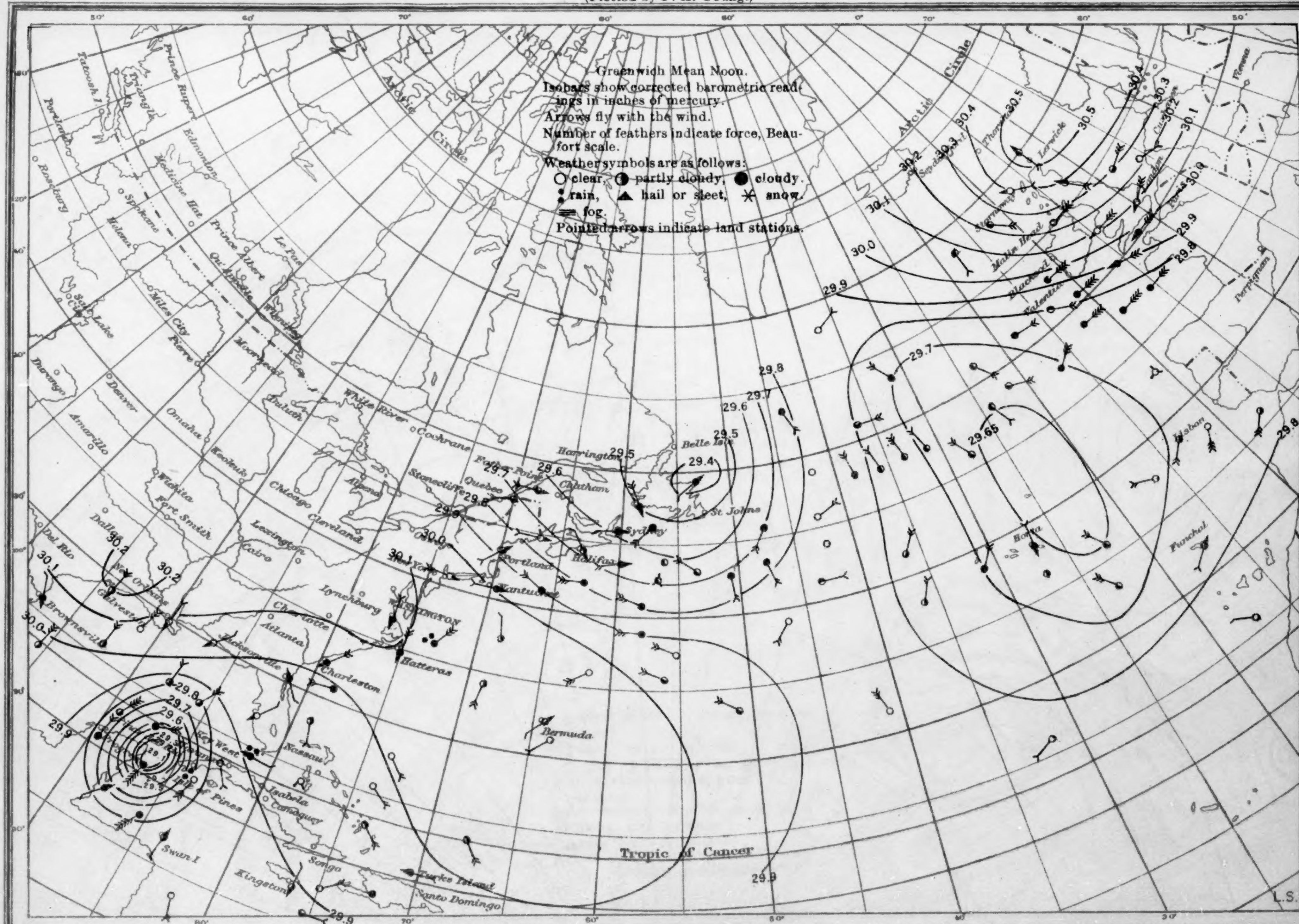


Chart XI. Weather Map of North Atlantic Ocean, October 19, 1922.

(Plotted by F. A. Young.)

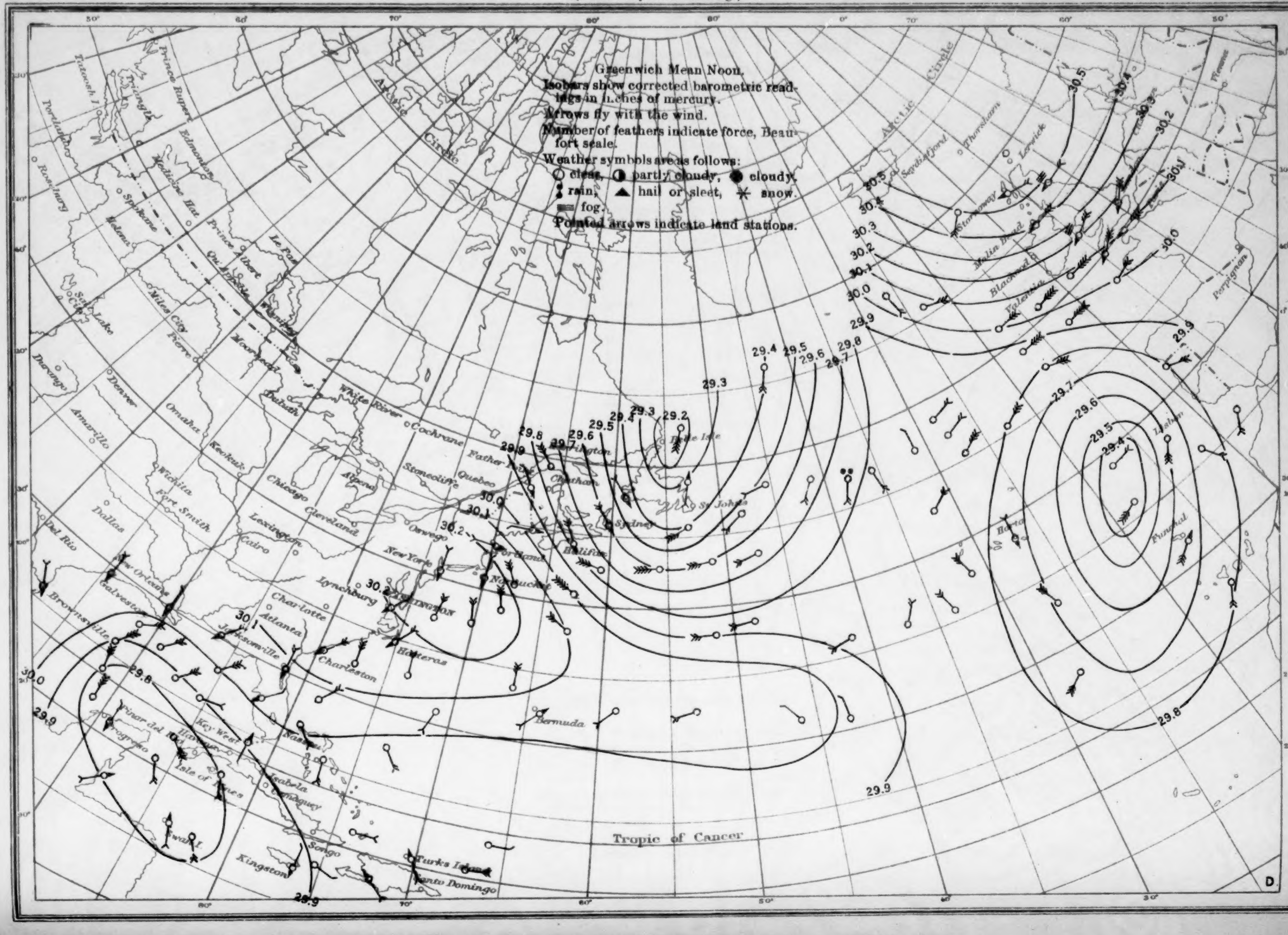


Chart XII. Weather Map of North Atlantic Ocean, October 20, 1922.

Chart XII. Weather Map of North Atlantic Ocean, October 20, 1922.
(Plotted by F. A. Young.)

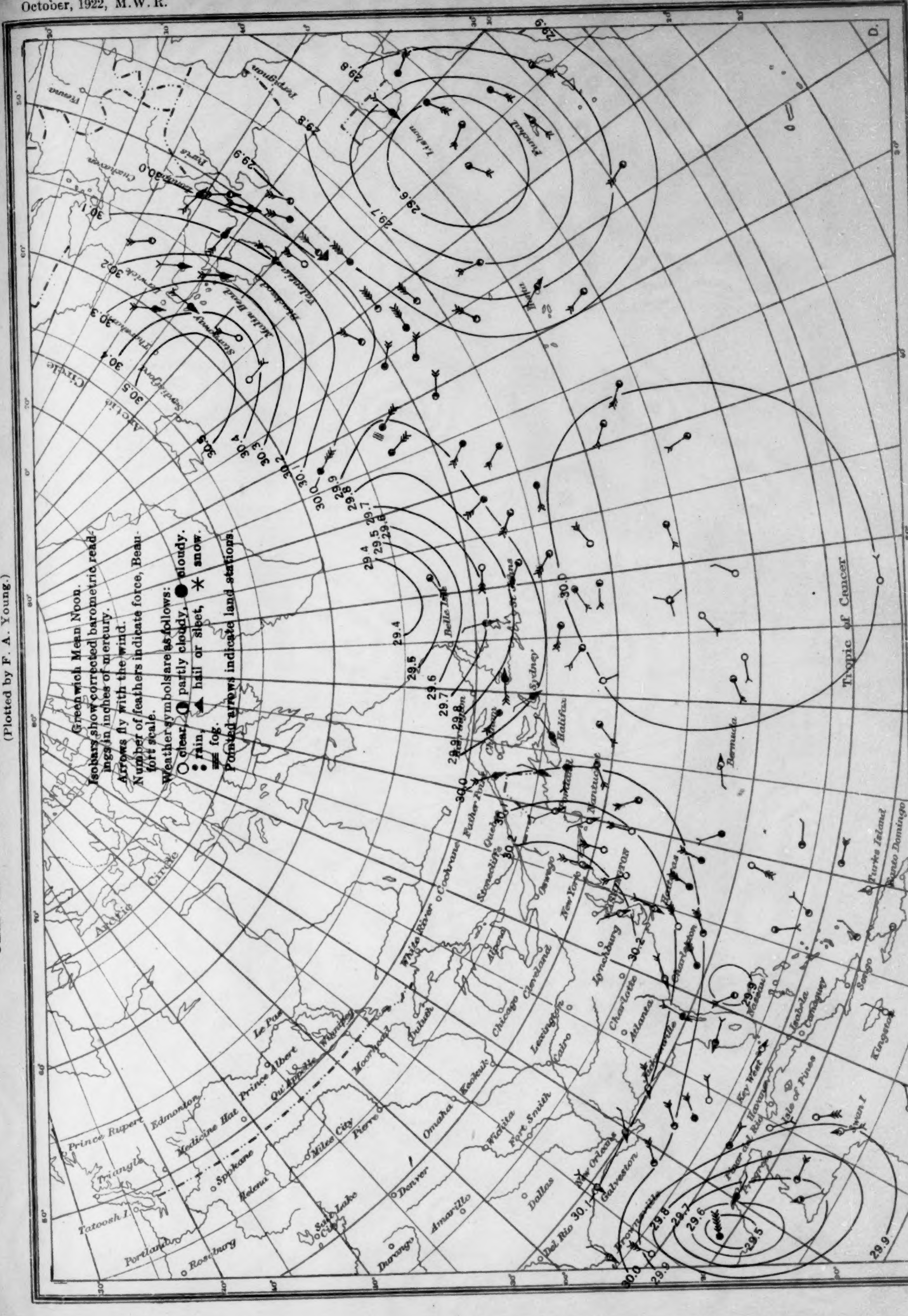
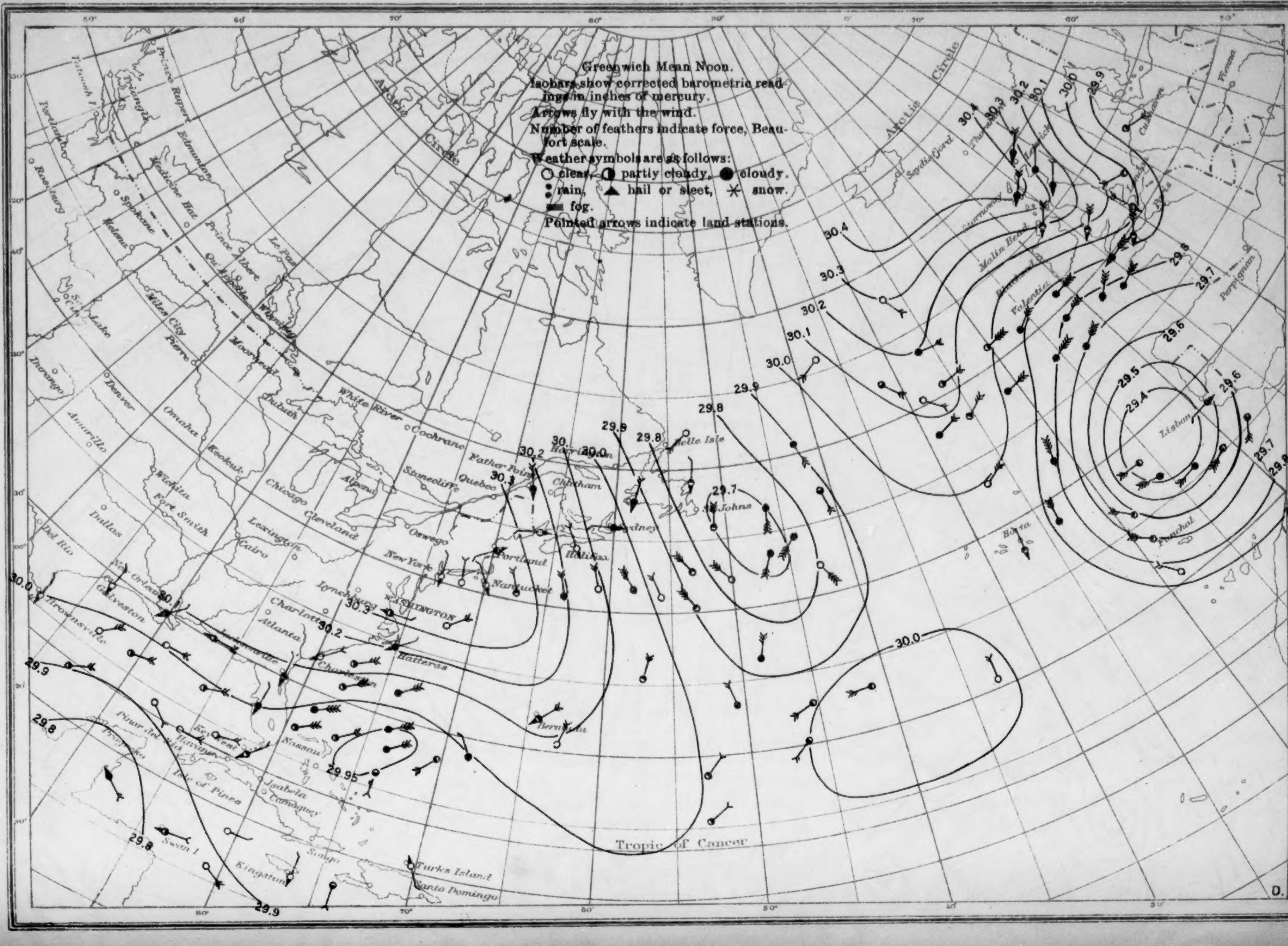


Chart XIII. Weather Map of North Atlantic Ocean, October 21, 1922.

(Plotted by F. A. Young.)



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OCTOBER, 1922.

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† In marine separate.